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19 August 1980

Worldwide Report

ENVIRONMENTAL QUALITY

No. 265

FBIS FOREIGN BROADCAST INFORMATION SERVICE

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BRIEFS

BAY OF BENGAL EROSION--Chittagong, June 14--About 600 acres of land along the coastal belt of Chittagong city had been devoured by erosion during last three years. According to the engineers of Coastal Embankment Project, the erosion is now taking a serious turn particularly between Kattali Union of Double mooring Thana and Kumira Union of Satkania Thana under this belt. The Bay of Bengal is engulfing the land at an average rate of 60 feet per month. This unabated erosion caused the expansion of the Bay of Bengal up to Chittagong-Dacca Trunk Road and Chittagong-Dacca railway lines. The village Sonalchari under Samilpur Union is now within half a mile of the sea. The erosion threatened the very existence of many mills and industries along this coast the industrial units include some jute mills. The Water Development Board has worked out a Taka 80 crore project for protecting the coastal belt between Patenga and Kumira from erosion. The works under the project have not yet started. [Text] [Dacca THE BANGLADESH OBSERVER in English 15 Jun 80 p 1]

CSO: 5000

INDIA

PROBLEMS OF AIR POLLUTION DISCUSSED

Madras THE HINDU in English 16 Jun 80 p 7

[Article by S. Parthasarathi]

[Text] IT is a popular misconception that almost everything present in the earth's atmosphere except nitrogen, oxygen and water and a few inert gases are air pollutants or remnants of pollution activities. There are sources in natural environment of a wide variety of gaseous and particle materials which are commonly classed as air pollutants when they are emptied by manmade sources.

In discussions on air pollution, the assumption is often made that pollutants once released into the atmosphere will disappear as soon as the air mass moves across. Just as often, it is also assumed that commonly identified pollutants are uniquely related to man's activity and that atmospheric pollutant emissions constitute a permanent and ever-worsening burden on our atmospheric environment.

Both these assumptions are drastic over simplifications. Let us examine our present state of knowledge of the atmospheric cycles followed by a variety of common gaseous materials generally met with in India.

The type and quantity of airborne wastes received by the atmosphere affect the ability of the atmosphere to supply animals and industry with the inputs they require. Although it would be of great interest to develop quantitative estimates of different atmospheric inputs into economic activity, such estimates do not seem to be available for any country, much less for India. The only fact that is known is that India like other countries is consuming more oxygen each year than its own vegetation produces

The emission of sulphur into the atmosphere has developed into one of the major pollution problems. Sulphur in the atmosphere comes from both the natural environment and air pollution emissions. The natural sulphur is represented by surface aerosols produced by the sea as well as by hydrogen sulphide from the decomposition of organic matter in swamps.

The magnitude of production of hydrogen sulphide from swamps in India has been speculative based on no definite data of estimates of concentration in ambient atmosphere. On the other hand, SO2 (Sulphur dioxide) emissions from pollution sources have been assumed on a worldwide basis including from India. A total annual emission of SO2 is estimated at 146 x 10^6 tons (78 x 10^6 tons sulphur). Of this total, 70 per cent is estimated to come from coal combustion and 16 per cent from the combustion of petroleum products. The remaining tonnage is accounted for by petroleum refining operations, about 6 x 10^6 tons and by non-ferrous smelting, about 14 x 10^6 tons.

Since coal combustion is a major source of SO2, further discussion of this source is justified. The worst affected in the country in this respect is the Chembur area of Bombay. Madras is heavily polluted by SO2 emission at the Basin Bridge Zone and the Central Station area. Other areas in the south include Ramagundam, Visakhapatnam, parts of Cochin (Ambalamedu) and locations of cement plants.

In the vicinity of the cement

plants can be seen fine particles of silical, lime, bauxite, SO_2 floating in the air polluting the atmosphere affecting visibility and retarding growth of vegetation. Dust from cement plant chimneys gets deposited on the foliage of crops and on the soil. People living in the vicinity of cement plants have protested against industry polluting their environment. But their protect is not very loud as many among them are beneficiaries of this polluting activity in the nature of jobs, and incidental gains.

The Indian coal averages two per cent sulphur indicating an emission factor of 4T 100T. About 10 per cent of the sulphur in coal remains in the ash. Since the passage of the 1974 legislation, it is incumbent on industries using coal including thermal power stations to use highly efficient electrostatic precipitators to mitigate the problem of air pollution. One finds enforcement of this very lax.

In Kanpur the problem is very severe, and when the Mathura refinery goes on stream it will be accentuated further. The white marbles of the Taj at Agra, already blackened will be further corroded by the refinery's SO_2 emission. All the protest against the location of the refinery at Mathura by conservationists have been of no avail.

Air pollution analyses are typically concerned with compounds that are only present in low concentrations and they pose well-recognised adverse reactions. This generally does not hold for the most commonly emitted carbondioxide (CO_2) which is an integral factor in the life cycle of the earth itself. When pollutant emissions are tabulated, CO_2 emissions are neglected.

On the other hand, carbon monoxide (CO) has been considered an important atmospheric pollutant for many years because of its prevalence in automobile exhausts and in the effluent from poor combustion. In spite of the widespread knowledge of the toxicity of CO, there have been fatalities in many countries including India resulting from exposure to excessive CO.

CO pollution studies in urban atmospheres have been carried out in a number of cities of India including Madras, to determine whether specific segments of the urban population were exposed to toxic levels of CO. Scientists point out that CO emissions can be estimated with reasonable accuracy. On a worldwide basis, the total annual CO emission from combustion sources is 304 x 10^6 tons, or 2.8 x 10 g. Coal production on a global basis amounted to 3089 x 10^6 tons, in a recent year.

The major CO emissions come from automobile exhausts, from coal when used for power development, from industrial operations including rail and steamship use, residential and local uses of coke and gas plants. Petroleum refineries, grey iron foundries and kraft paper mills also emit CO during their operations.

There has been a significant deterioration in ambient air quality in the cities of Bombay, Calcutta, Madras and to a lesser extent in the other cities. Studies have been made to find out the health effects of airborne lead from automobiles in children living near major highways and the results are such as to cause worry.

Apart from lead, there are several other pollutants which are candidates for control—asbestos, beryllium, mercury, vinyl chloride, all designated as hazardous pollutants. Control strategies have not been upgraded in India in the light of the new information becoming available from foreign lands. Stringent emission standards are necessary and these should be enforced strictly.

CO is an important pollution enigma because in spite of its ubiquitous presence in the combustion gases, it is not possible to enumerate any known scavenging mechanisms in the environment itself.

The gradual gaining of understanding of air pollution has opened up new dimensions for air pollution problems. These are characterised by photochemical reactions occurring in the atmosphere and involving organic materials and nitrogen oxides and producing as by-products visibility reducing aerosols. Photochemical pollution was once considered a unique attribute of some of the highly developed locations in the advanced countries but in the past few years this has become an occurrence in all the world's major communities

Today the field of quality management is a complex of sociological, legal and technological problems. Legislation which aims at effective control must balance the social desirability of encouraging progress in consumer industries with the requirements for a healthy and satisfying civilisation.

ENVIRONMENTAL PROTECTION NEEDED FOR NATIONAL GROWTH

Calcutta THE STATESMAN in English 16 Jun 80 p 13

[Article by Achyutananda De]

[Text] WHITHER mankind? Human civilization cannot endure long if the reckless exploitation of natural resources continues unabated. Man is destroying nature's bounty indiscriminately to meet his increasing requirements and in the process digging his own grave. This must stop.

It is natural for a developing country to plan for increased industrial and agricultural output, but the prime consideration should be a mutually harmonious relationship with the physical environment which must not be allowed to be polluted or poisoned. The root cause of environmental problems is the population explosion, which has brought in its wake an accelerated rate of economic growth: that means an ever increasing amount of goods and materials to be produced, consumed and finally disposed of.

According to the Botanical Survey of India, the existence of 10 per cent of the world's plants is in jeopardy becuse of the disturbances in the environment. The increasing amounts of man-made chemicals being introduced in the environment have already caused unprecedented harmful effects. Some 4 million such chemicals are there and several hundred more new chemicals are being added every year.

Industrialization may be necessary to generate more employment by this should not be done at the cost of Nature. Discussions on the world conservation strategy in Delhi early this year highlighted the fact that preservation of the quality of the biosphere is not against the modernization required for all-round improvement in living standards.

According to ecologists "close to one-third of the world's arable land will be destroyed in the next 20 years if the current rate of land degradation continues". In the case of India, of 3.3 million sq kilometres, 1.4 million are subject to severe soil erosion while an additional 270,000 sq km are adversely affected by flood, salinity and alkalinity.

Since Independence, India has lost 4.10 million hectares of forest land. Even the developed countries do not resist the temptation of being reckless with Nature. According to the world conservation strategy report, 25,000 plant species and more than 1,000 vertebrate species are threatened with extinction largely through destruction of their habitat.

That apart, the growing threat of air and water pollution as a result of the fast pace of industrialization will be imperilling our future if we do not initiate a programme on a war-footing to protect the environment from the consequences of our action. Our waterways will continue to be poisoned until factories are forced to instal water-treatment plants.

Towards the end of this decade, India will have to provide the necessities of life for some 800 million people and 500 million farm animals. This has to be accomplished by enhancing rather than decreasing the productivity of land and water. But the most unfortunate part of it all is that almost all the main rivers in India, including the Ganga and Yamuna, have been polluted by industrial waste.

All these rivers provide not only drinking water but also water for irrigation purposes. The

Asansol-Durgapur belt is in the grip of environmental pollution. Even Calcutta is not free from these hazards. The 16-km stretch of Tolly's Nullah has been a real health hazard. Reports have it that the Victoria Memorial and Birla Planetorium are located in the worst polluted area of the city. Levels of carbon-monoxide are possibly the highest in Calcutta because of the slow and very heavy traffic jammed for long periods generally in the evenings. Emissions from petrol engines, though for the most part not visible are more harmful than diesel engine emissions.

Pollution in the Hooghly is assuming alarming proportions the main cause being the ever-increasing number of small and big industries along its banks. But, according to the National Environmental Engineering Research Institute the situation has not yet reached a crisis point because of the depth and breadth of the river.

Some measures suggested to counter the problem of pollution are the setting up of an environmental control board to keep vigil over the entire metropolitan area. As a check on industrial emissions, a suitable monitoring squad should be instituted. Proper planning of vehicular traffic along with periodic checks on engine vehicles is the need of the hour. Calcutta's basic water and sewage systems are more than a hundred years old. But over the last century the population of the city has increased from 800,000 to over eight million. Unless urgent steps are taken to modernize them, it may not be long before the chain of open drains in many parts of the city and ailing water treatment plants on the Hooghly (which is the main drain as well as the major source of water supply) result in severe health hazards.

Calcutta is not an isolated example. According to a World Health Organization survey in 1970, more than half of the inhabitants of the Third World are not served by any regular water supply system. Even Delhi faces a water problem every summer. The same may be said of many State capitals, let alone small towns and villages. Chronic respiratory troubles are much higher in Calcutta where the air is thick with industrial, automobile and domestic emissions, which contribute 670 tonnes of pollutants every day. The major agents of pollution are carbon-monoxide, sulphur-dioxide, nitrogen-dioxide, hydro-carbons and suspended particulate matter which has been identified as "the single largest culprit contributing nearly 300 metric tonnes a day to the daily pollution of 670 metric tonnes."

The presence of these particulates is mainly due to the heavy consumption of low-grade coal by domestic and industrial consumers. The use of soft coke in the lighting of domestic fires is in itself a major problem and contributes 78 tonnes of pollutants daily. The dense smoke from these "chulas" settle over the city like a blanket every morning and evening. The Bengal Smoke Nuisance Act, which has been in vogue since 1905 is outdated and no attempts have been made to update it. Its scope should be enlarged to the extent required.

The highest emission is by chemical industries according to a NEERI study of 81 chemical units which emit nearly 30 tonnes of pollutants a day. That the Government is alive to the danger of pollution is evident from the letter the Prime Minister has recently sent to all States impressing upon them the necessity of protecting the environment. The Union Agriculture Minister Rao Birendra Singh's announcement at the inauguration of the World Conservative Strategy that a revised national forest policy would be considered to lay greater emphasis on environment is an indication of the Government's determination to care for forests.

CSO: 4220

BRIEFS

HOOGHLY SALINITY DOUBLES--Calcutta, June 14--Steep rise in salinity of the Hooghly waters has posed a problem for the Haldia Development Board. It is looking for alternative source of drinking water. Salinity has almost doubled, according to an official spokesman. It was 2500 PPM at Geonkhali point and has now risen to 5,000 PPM. The abnormal rise in salinity in the Hooghly waters said to have been caused by the reduced discharge of headwaters at Farakka. [Text] [New Delhi PATRIOT in English 15 Jun 80 p 5]

CSO: 5000

POLLUTION PROBLEM IN GUANGZHOU RESIDENTIAL AREA REPORTED

Guangzhou NANFANG RIBAO in Chinese 4 Jul 80 p 1

[Letter to the Editor from Residents at 81 Martyrs Road, Guangzhou City: "Dongshan District Foundry No 2 Should Eliminate Pollution Immediately"]

[Text] Dear Editor:

We are workers of the Guangzhou Institute of Electronic Technology under the Chinese Academy of Sciences. Near our residential quarters, large quantities of wast fumes, waste gases and loud noises are produced by Dongshan District Foundry No 2 during production hours, seriously polluting the environment and impairing the health of the residents in the neighborhood. It has become imperative to take remedial measures.

Because the site of Dongshan District Foundry No 2 is situated right in the midst of a residential area with hospitals, nursuries and research institutes, it is not a suitable location for building the plant in the first place. Now, this plant is ever expanding, while dust, coal gas and the dense fumes of poisonous substances such as sulphides are being diffused all over the area. The tables and chairs in our dormitories are often covered with black dust; the irritant poisonous gases cause people to feel suffocated and develop such diseases as laryngitis and bronchitis. Night and day, in all three daily shifts, loud noises come from the plant's two cast polishers which prevent us from resting at noon and night. Tortured by the noises, many comrades suffer from fatigue or fast heart palpitation, and feel frustrated all day long.

Beginning last year, we contacted the plant many times, hoping that they would take effective measures to reduce the smoke, dust and noise pollution. At first, they said: "Don't interfere with us", and "you'll get used to it." Then we were told that they could not afford pollution prevention equipment, and had to wait for the money. Thus, the problem still remains unsolved today. The air force clinic also failed to convince them, and not long ago, they had to move away. Other organizations simply have no choice but to grin and bear the frustrating situation of having to have to "close the windows in summer to keep out poisonous gases, and put up with sleepless nights."

We are scientific and technical workers who are anxious to serve the four moernizations. But this kind of environment prevents us from studying, working and resting, and we are really worried. We hope that concerned departments can help us solve the problem.

Residents of 81 Martyrs Road, Guangzhou City

9119
CSO: 5000

'RED TIDE' IN GUANGDONG'S ZHANJIANG BAY REPORTED

Guangzhou NANFANG RIBAO in Chinese 30 Jun 80 p 2

[ARticle by Huang Zhimin [7806 2535 3046] and He Shaoying [0146 1421 5391]: "Massive 'Red Tide' Appears in Zhanjiang Bay"]

[Text] On May 18-24, a massive "red tide" appeared in Zhanjiang Bay. During the "red tide" period, variations occurred in the sea water: there was an acute increase of suspended matter accompanied by stale odor, and the number of fish and prawns decreased. As ships and boats sailed in the harbor, long trails of bubbles measuring 2 nautical miles were left behind in the water, and did not disappear (normally, bubbles disappear within 200 meters).

"Red tide", otherwise known as "scarlet tide", is the result of sea water deterioration and color variations brought about by the large increase of phosphorous and oxygen nutrient salts as well as iron and manganese trace elements which cause a kind of low class planktons known as mini-column algae to reproduce at an abnormally rapid rate, and another group of plankton or plants to rapidly die and decay, which is the result of sea water pollution. "Red tides" occur mostly in high temperature seasons in nearshore bays or land-locked inland seas which do not have adequate water exchange. When "red tides" occur, the massive reproduction, death and decay of plankton consume the dissolved oxygen contents in the sea water, causing a grave shortage of oxygen in the sea water. As a result, organic substances disintegrate into methane, hydrogen sulfide, etc., which, together with the reproduction of poisonous plankton, cause large numbers of fish, shellfish, crabs, shrimps, etc. to die of suffocation or poisoning. The "red tide" in Zhanjiang was primarily caused by the drainage of large quantities of industrial waste water and sewage from civilian homes into the sea. It has gained the attention of concerned organizations who are already engaged in research on ways of preventing it from happening again.

9119
CSO: 5000

PEOPLE'S REPUBLIC OF CHINA

BRIEFS

PAPER FACTORY RECYCLES WASTE--Situated next to Suzhou's famous Hanshan Temple, the Huasheng Paper Factory used to seriously pollute the scenic spot, which not only drew bitter criticism from the masses, but also made foreign guests unhappy. Once, a Japanese friend criticized the paper factory for polluting the environment. He changed two sentences in a poem "Maple Bridge Evening Lake" by the Tang poet Zhang Ju: "The odorous smell of paper comes to the beds at night; so many people can not sleep at all." Through one year's effort, the plant finally eliminated the black liquid produced from paper production, and used new techniques to recycle the wasts liquids, thus achieving encouraging results in pollution control. The Huasheng Paper Factory used to discharge 35,000 tons of black liquid and other waste liquids each day. To solve the problem, they built a caustic soda recycling unit. Ever since it was put into operational mode, the equipment has been recycling some 60 tons of caustic soda per month, thus providing a preliminary solution to the black liquid pollution problem. In coordination with other organizations, they have also succeeded in applying, for the first time, the efflux gas flotation technology in paper making production; 2 tons of talcum powder and small fibers are recycled daily, and 2,400 tons of water are purified each day. Now, they have reduced the amount of water for paper bleaching from 200 tons to approximately 40 tons, thus reaching the country's advanced level. The entire plant's daily waste liquid discharge rate has been reduced by 23 percent, and the organic contents in the waste liquids have been reduced from 120 tons to 40 tons. [Text] [Beijing GONGREN RIBAO in Chinese 12 Jun 80 p 2] 9119

IMPROVE PRODUCTION TECHNOLOGY--The Shanghai Dongfent Non-Ferrous Alloy Plant has achieved remarkable results in controlling the three wastes through technical reforms. Within the short span of 2 years, they have effectively controlled cadmium pollution, and promoted the development of production, thus increasing the entire plant's production capacity from the annual yield of 7,000 tons to over 10,000 tons. The Dongfeng Non-Ferrous Alloy Plant is one of Shanghai's largest users of cadmium. As the evaporation temperature of cadium is relatively low, large quantities of zinc and cadmium are evaporated in the process of smelting. As a result, the cadmium contents in the air in the workship is 18 times over the national standard, and the cadmium contents in the dust is 2,000 times over the national standard. To thoroughly eliminate cadmium pollution, the plant started out by improving the smelting process; they converted the diesel fuel reverberatory furnace into a low frequency induction furnace, thus reducing the furnace temperature from 1,200 degrees to below 500 degrees, and effectively controlled cadmium evaporation. Over the past year, they also replaced the old iron casting moulds with semi-continuous casting machines, and replaced dust sweepers with dust-bag collectors. This way, they basically eliminated the smoke and cadmium contaminators from the smelting process. Thanks to the improvements made in production technology, the metal consumption rate has dropped 45 kg per ton, the product cost is down 50 yuan per ton, and the profit gains amount to nearly 1 million yuan. [Text] [Beijing GONGREN RIBAO in Chinese 12 Jun 80 p 2] 9119

SMALL TOWN POLLUTION--With the development of industry, environmental pollution caused by industrial waste gases, waste liquids and waste residues has also occurred in medium and small towns. But the problem has failed to gain the attention of concerned leading departments and enterprises. Recently, one of our reporters visited Hubei Province where he witnessed the serious calamities brought to the people in many towns by the "three wastes". In Hubei's Guanghua County, there is a primary school located at Laohekou which is confronted by a nitrogen fertilizer plant in the southeast, an agricultural chemical plant in the south, and the sulphuric acid workshop of a phosporous fertilizer plant in the west. Whenever a wind blows in the direction of the school, the people are either suffocated by ammonium gas, or covered by a canopy of sulphuric acid smog. The campus is filled with poisonous gases. Unable to open their eyes, the teachers and students cough without stop, and shed tears. The moment the residents in the neighborhood spot smoke and dust, both grownups and children cry out: "The smoke is here!" and instantly shut the doors. As soon as the smoke and gas clear up, some children beat washbasins and shout: "All is well!" In Hubei's Huangpo County, four water pools covering 80 mu are contaminated by waste water from the tawing process of a leather factory, thus causing a drinking water problems for the local peasants who have lodged sharp protests. Laoheke and Huangpo County are by no means exceptional cases. We should call the attention of concerned parties to take effective measures and incorporate the "three wastes" control projects in medium and small towns into the overall control plan. This way, the state's "environmental protection law" can be enforced in all corners of the country. [Text] [Beijing GONGREN RIBAO in Chinese 12 Jun 80 p 2] 9119

CSO: 5000

INDUSTRIAL POLLUTION IN CHAO PHRAYA KILLING MARINE LIFE

Kathmandu THE RISING NEPAL in English 22 Jul 80 p 3

[Text] Bangkok--Death is threatening thousands of seagulls in the capital city and concerned officials say the culprit is pollution. But what is worse is the fact that the same threat also hangs over villagers, especially children.

Only 30 kilometres from the heart of this city, no more seagulls except for a few can be seen near the mouth of Chao Phraya, the main river which runs through Bangkok. The potential extinction of the seagulls is attributed by researchers to polluted fish and crustacean which birds feed on near the river's mouth.

According to studies made by the Environment Research Institute (ERI) of Chulalongkorn University, "DDT and other poisonous chemicals in the river mouth have caused fragility to seagulls' eggs. The eggs may be broken before they are hatched.

The ERI has found that only three micrograms of poisonous chemicals out of one gram of food eaten by a mother seagull can adversely affect its eggs.

Formerly there were thousands of seagulls at Bangpoo, a nearby village, especially during the cold season from November to February. The seagulls would lay eggs during this time. "Today we see only a few, even during the cold season. We don't know why," a Bangpoo fisherman said.

Researchers could have the answer--industrial wastes dumped into the river mouth have contaminated its marine life which the seagulls eat (fish and crustacean). The poisons include DDT, mercury, lead and cadmium, apart from organic wastes discharged by distilleries and beer factories.

The birds usually follow the boats which dump the wastes into the Gulf of Thailand. With their rhythmic wing beats, they swoop innocently down on the contaminated food.

"Someday the Gulf of Thailand would become a pool of dirty water, full of pollutants and very few living creatures," says ERI Director, Dr. Thaweesak Pivakarn.

But what ERI researchers and the Office of the National Environment Commission fear most is not the extinction of seagulls at Bangpoo but rather the effects of pollution on newborn children at the coastal villages near the Chao Phraya River's mouth.

The seagulls' story is minor when compared to the tragedy two years ago in a nearby town of Phrapradaeng in the Gulf province of Samutprakarn. A worker's family lost one child from lead poisoning when the father unwisely used discarded batteries on a muddy lateral groundway in front of his house.

His youngest two-year-old kid vomitted and could not eat after several months. Taking the child to a government hospital, a doctor diagnosed it as lead poisoning. The child died two days later.

Similar illnesses have hit other children and the Interior Ministry has long ordered the batteries dug out of the village and dumped far away from the community.

Recently a local feature magazine ran a scoop story on chemical pollution from wastes discharged by a caustic soda and a seasoning powder factory at Leam Fapha village in the Muang district of the same province.

"Let's call this village the Village of Chemical Pollution," the reporter of the magazine said. Going after the story this reporter found hills of chemical wastes left over from caustic soda and seasoning powder production processings.

The companies involved, the Thai Asahi Caustic Soda and the Ajinomoto (Thailand), for the past several years have dumped truckloads of their wastes into an area where mangrove trees used to grow. They cut down the trees and dug ponds for the wastes. The companies hoped that by dumping their processing wastes into the ground the danger from industrial pollution would be lessened.

However, when the rains come, polluted water from the dumping sites spills over to nearby fish and shrimp farming ponds belonging to villagers. Toxic chemical pollutants like mercury, lead or cadmium are then transmitted to the fish or shrimp ponds and thus enter the food chain.

The sites where chemical wastes from the two industrial plants are being dumped are badly affected. Big and small trees and even weeds at the sites have died because of the pollution.

During the dry season, the dust of chemical wastes would be blown by wind into Watlaem School, the only primary school in Laem Fapha village, and is inhaled by students as well as teachers.

"I have noticed that recently some of my students have shown the symptoms of getting too much of the chemical pollutants. They often faint with blood from their noses and have become very weak," a teacher of Watlaem said.

Three years ago when the caustic soda and seasoning powder plants started dumping their production wastes at Laem Fapha village, the villagers launched several protests calling for the companies to move their dumping sites elsewhere far away from the village. Their protests were not heeded, however, and the authorities involved were unable to protect them.

"The companies even tried to bribe the villagers by distributing seasoning powder to the inhabitants or buying new uniforms and exercise books for the students at Watlaem School," the same teacher said.--(Depthnews)

CSO: 5000

BANRURAL MANAGER EXPRESSES CONCERN OVER CROPS

Culiacan EL SOL DE SINALOA in Spanish 9 Jul 80 pp 1, 5

[Text] The officials of the Rural Credit Bank [BANRURAL] of the North Pacific are worried because the rainy season has not yet stabilized, even though 90 percent of the area, consisting of 82,000 hectares in the municipalities of Mocorito, Badiraguato and Culiacan, has now been prepared.

Engineer Guillermo Kabata Rosas, the local manager of BANRURAL, explained yesterday that the scant rainfall that has occurred is not yet insuring favorable conditions for the planting in the stormy weather areas.

He explained that, of the 82,000 hectares programmed, 42,000 are to be used for sorghum, 33,000 for corn and 6,000 for sesame seed; for which purpose a line of credit totaling 250 million pesos is available.

He also explained that the stormy weather crop farmers have been given part of the credit to prepare the soil and to purchase seed and that everything is ready to start the planting as soon as the conditions are present.

He noted, in addition, that part of the land has been given dry fertilizer, and all that is being awaited is for the "land to be accommodating" to begin the planting.

Engineer Kabata Rosas remarked that the technical personnel in the irrigated districts have been moved to the stormy weather area to help the farmers with technical assistance, from the preparation of the soil to guidance on the seed that they should use in each instance.

Despite the concern that exists among both the farmers and the bank itself, engineer Kabata Rosas pointed out that there is confidence that, by 10 July, the rainfall in central zone of Sinaloa will be more constant, and the planting can begin. He gave a reminder that, last year too, the rain was not widespread until 10 July; but that it was lacking at the end, in September, causing the agricultural disaster, which it is feared may be repeated this time if there is not a regular rainy season.

2909
CSO: 5000

AGRICULTURAL SITUATION IN CHIHUAHUA CALLED DISASTROUS

Nuevo Laredo EL MANANA in Spanish 6 Jul 80 p 5

[Text] Mexico City, 5 Jul (EXCELSIOR)--The head of the Chihuahuan Regional Cattlemen's Union, Alfonso Ramos Sanchez, said that, with pastures razed and 40,000 animals dead, the situation in the state due to the drought is "disastrous," while the damage to agriculture from the same phenomenon in Nuevo Leon, Tamaulipas, Aguascalientes, Guerrero and Oaxaca is serious.

In Chihuahua, it was reported that the situation is critical: During the past 24 hours there has been imperceptible rainfall and the temperatures continue to be quite high: in Ojinaga, 46 degrees; in Camargo and Ciudad Juarez, 40; and in Jimenez, between 38 and 40 degrees.

The head of the cattlemen, Ramos Sanchez, said that it is pitiful to tour the Chihuahua countryside, where there are thousands of dead cattle emitting an unbearable odor; and he complained of the lack of understanding on the part of the federal government, which has not granted permits for the exporting of yearling bulls, nor for the importing of feed for the herds, something which has exacerbated the situation.

In Nuevo Leon, it was reported that the drought has ravaged agriculture and the livestock industry. There is a water shortage in Monterrey, and the hospitals are treating about 20 children each day for dehydration. The water shortage has increased the protests from housewives, especially in the public housing developments, where it is needed to meet the most basic needs.

In Nuevo Laredo, Tamaulipas, it was noted that if there is no rain within a few days the stormy weather crops will be lost. According to the report submitted by the representative from SARH [Secretariat of Agriculture and Water Resources], Jose Carlos Gonzalez, sufficient rainfall to save the crops is needed.

In Aguascalientes, the state agricultural-livestock office authorized the dry planting of corn and beans on 116,000 hectares of stormy weather crop land, starting on 10 July. It was admitted that the chances of obtaining a harvest have been reduced by the delay in the rainfall in most of the state.

The public officials decided to authorize the planting, "whether or not there is rain," in view of the fact that, on 25 July, the official timetable expires, and the crops will subsequently run the risk of the early frosts.

2909
CSO: 5000

NUEVO LAREDO AREA CORN, SORGHUM CROPS MAY BE LOST

Nuevo Laredo EL MANANA in Spanish 26 Jun 80 Sec B p 1

[Text] A tragic outlook is being discerned by those who planted stormy weather crops in the area because, at the moment, they are facing the loss of 50 percent of the newly sprouted plants; and they report that, if it does not rain within 20 days, they will lose the sorghum and corn crops covering between 800 and 1,000 hectares.

The foregoing statement was made by the general secretary of the Fifth Communal Farm Zone, Francisco Santos Villarreal, who claimed that every day the situation is becoming more critical in the countryside owing to the lack of rain and the tremendous heat wave that is being experienced.

According to the head of the farmers, the little water which the soil received from the precipitation at the end of May has vanished, and this is why at present 50 percent of the plants that have been sown on the stormy weather areas exposed to the rain have been lost.

Santos Villarreal declared that if there is no rainfall within the next 20 days, the effort, money and labor of the communal farmers of the region will be wasted. Upon testing the moisture that their land received at first, they immediately began planting seed in the furrows in the hope of growing a crop.

Yesterday, an official spokesman from the Secretariat of Agriculture and Water Resources stated that there has also been a tendency on the part of the government of the republic to raise the guarantee prices of basic products, in order to foster an increase in the crops, especially the corn, beans and wheat.

It is planned to promote the basic crops needed by the population in a number of different ways, and the Secretariat of Agriculture and Water Resources (SARH) will definitely participate therein.

Noteworthy among the SARH's immediate plans is artificial rain resulting from the seeding of clouds with silver nitrate. The secretariat's spokesman said that experiments with this rain are being conducted in the Rio Bravo region in Tamaulipas with good results. He noted that the government is attempting to assist the rural productive sector with programs involving large investments, so as thereby to alleviate the critical situation which prevails there.

He also disclosed that Nuevo Laredo's weather problems stem from the fact that it is contained in a desert area and, consequently, there is little rain.

2909
CSO: 5000

AGRARIAN REFORM AGENT SEES LATE CROP PLANTING JEOPARDIZED

Nuevo Laredo EL DIARIO DE NUEVO LAREDO in Spanish 5 Jul 80 Sec B p 1

[Text] The few crops planted in this region based on stormy weather rainfall are entering their critical stage, because, if there is not a considerable amount of precipitation in the countryside, all hope of a late crop planting will be lost.

This statement was made to our reporter by the regional agrarian reform agent, Jose Carlos Gonzalez, who added that the second half of July is the period when the soil should receive considerable rainfall in order to make a late crop planting feasible.

The agrarian reform official noted that there must be an average rainfall of 3 inches per day over a period of about 15 days in order to warrant any hope of a remarkable change in the situation of the rural areas.

Such precipitation would remedy the situation for a long period of time, because less rain would not benefit anyone, since the process of evaporation of the soil during this season is five tenths of an inch per day.

In order for the soil to be provided with moisturs and for conditions to be propitious for planting, a considerable volume of water must be out of reach of evaporation; in other words, accumulations of moisture caused only by long rainy seasons.

In conclusion, Carlos Gonzalez said that next week and the last part of July will be the keys to the future of the Mexican countryside in this region; because, if there is not abundant rainfall then, or within the next 21 days, the farms who risk the stormy weather late crop planting may have no hope of doing so.

2909
CSO: 5000

CATTLEMEN BLAME CONASUPO MISMANAGEMENT FOR LOSSES

Nuevo Laredo EL MANANA in Spanish 4 Jul 80 Sec A p 5

[Text] Mexico City, 3 Jul (TIP-CISA)--The National Cattlemen's Association stated today that the drought in Mexico has caused cattle raisers to lose 320 million pesos spent on daily feed for the livestock.

Arturo de la Garza, national head of the cattlemen, said that the drought is affecting them "because we have to spend 10 pesos per day for each of the 32 million head of cattle that we have, to give them better feed."

He added that, "These supplements must be made because the Government Basic Commodities Company [CONASUPO] has failed in the purchase and supply of sorghum."

The 500,000 cattlemen affiliated with the confederation have reported to Arturo de la Garza the existence of surplus beef production.

He said, "We also have overproduction of poultry, which causes the prices to drop," admitting that milk, beef and egg prices are still rising, "owing to the inflationary spiral affecting the country."

He subsequently stressed that eggs, for example, "were priced at 9 pesos the week before last, which is 10 pesos under the official price," and noted that the consumer is still receiving the item for 22 pesos.

To the cattlemen's leader, the explanation for this situation lies in the poor "organization" and poor "marketing system in Mexico."

The leader emphasized that the problem will worsen "when the industry's capital becomes depleted because it fails to receive the necessary incentives." He stressed that the surplus production of beef and eggs does not mean that they have not been hurt by the intense drought experienced in the country and that, on the contrary, its results will soon be evident.

According to the cattle association official, the situation is not the same in pork production, which has declined 33 percent.

The blame for the aforementioned problem was again directed at CONASUPO, for not supplying sorghum nor giving assurance that the grain supply would become normalized.

On the subject of the cuts in electric power ordered by the Federal Electricity Commission, for the purpose of saving 13.5 million kilowatts, he said:

"That has not affected us. It is all a matter of scheduling the orders, so as to prevent a standstill when the cut in power is made."

2909
CSO: 5000

NUEVO LAREDO AREA CATTLEMEN REPORT LOSSES

Nuevo Laredo EL DIARIO DE NUEVO LAREDO in Spanish 5 Jul 80 Sec B p 1

[Text] The situation in the rural areas resulting from the dearth of rainfall (which has lasted for over a year) has been described as critical by the region's cattle raisers, who claim that, if it continues, very urgent measures will have to be adopted to prevent the complete decimation of the livestock.

In an interview held at noon yesterday with Mr Raymundo Rios Mayo (manager of the local cattlemen's union), he reported to EL DIARIO that, according to the statistics that have been recorded, about 1,500 head of cattle have perished to date.

Mr Rios Mayo said: "When we consider the fact that the drought has lasted for more than a year the statistics show that the situation is far more critical than in previous years;" adding that, in view of these circumstances, the local cattlemen's union has found it necessary to seek a speedup in the permits for importing feed supplements for the herds.

Mr Rios Mayo noted that, because of the forage shortage due to lack of water, the cattlemen are concerned with obtaining imported fodder so as to keep their animals surviving, particularly the breeding cows and bulls.

Every day, the cattle raisers report to the local cattlemen's union on the situation in their summer pastures. The water shortage is causing deaths among the bovine herds. Some animals succumb for lack of feed, and others are in danger of dying because they have already begun showing signs of organic deficiencies.

It Has Rained, But Not Enough

The statistics gathered by the local cattlemen's union indicate that the rainfall in the region has been scant since June of last year.

Raymundo Rios Mayo declared: "Although it is true that it has rained in some areas, the water has not been at all sufficient to alleviate the situation."

The rainfall has been light, and has not benefited the agricultural and livestock sector at all; therefore, the situation is becoming critical, especially for the cattlemen who are watching their animals die with great concern.

In addition to the lack of water and forage, the bovine herds are exposed to high temperatures, which are reaching as much as 45 degrees centigrade on the thermometers at present.

2909
CSO: 5000

CATTLEMEN SEEK MEAT EXPORTS, FEED IMPORTS

Ciudad Juarez EL FRONTERIZO in Spanish 10 Jul 80 pp 1, 10

[Text] Mexico City, 9 Jul (OEM)--The longest drought in recent decades has struck 10 million head of cattle in the north. To date, it has caused the death of 100,000 animals in Chihuahua and 30,000 in Sonora, as well as losses in excess of a billion pesos.

In view of this situation, the board of directors of the National Cattlemen's Association has requested of the Secretariat of Agriculture and Water Resources permission to slaughter surplus thin livestock for export to the United States, and to export boned meat, as well as to import feed and forage, so that the livestock will not continue to die.

Yesterday afternoon, the head of the CNG, Arturo de la Garza, announced: "Because of the delay in the rain, the situation is critical in Chihuahua, Sonora, Zacatecas, Coahuila, Nuevo Leon and Tamaulipas. In addition to the delay in the precipitation, it has only occurred in very limited areas."

At the moment, Chihuahua is the state with the most serious problems resulting from lack of rain. To date, 100,000 cattle have died, and in Sonora the total is 30,000. The economic losses easily exceed a billion pesos.

Because of the lack of pasturage and forage, the cattlemen are also faced with the problem of keeping the breeding ranches in operation: There are 10 million head, for which 10 billion additional pesos have already been spent, with a view to reducing the national cattle inventory, which is currently 32 million head. This money has been obtained through loans from private and government banks.

The CNG head stated: "To solve this problem, we are asking the pertinent authorities to allow the slaughter of surplus thin cattle which are most likely to die from lack of feed, and to market it in the United States.

Why is this type of lean meat not sold on the domestic market at low prices? The answer from the leader of the country's 360,000 organized cattle raisers was:

"The domestic market is saturated with meat from fattened cattle. It is not true that there is no meat on the iron hooks, because in the Sonora cattle pens alone there are currently 150,000 head of fattened cattle. There are also cattle pens in Coahuila, Chihuahua, Durango and North Veracruz. Every day, animals arrive in the Federal District from Tabasco, Máchoacan, Veracruz, Chiapas, Campeche, Nayarit and the San Luis Potosi Huasteca region. A total of 760,000 animals per year are fattened to meet the demand in Mexico City alone."

For this reason, he said, there is no market for that type of boned meat which, on the other hand, is in great demand in the United States for making hamburger.

In conclusion, he remarked that the drought has affected 33 percent of the national livestock to a greater or lesser degreee, with its ravages. De la Garza Gonzalez stressed: "No one is to blame for this, either the government or the producers, but rather the weather factors."

2909
CSO: 5000

MEXICO

BRIEFS

CHIHUAHUA CATTLEMEN COMPLAIN--Mexico City, 1 Jul--The head of the Chihuahua Cattlemen's Union, Baltazar Quezada, stated that 100,000 head of cattle have died as a result of the drought which has struck the country's northern states for 11 months. In a telephone interview with UNITED PRESS INTERNATIONAL, Quezada said that the drought had also caused losses amounting to $80 million. He added that, in Chihuahua alone, about 60,000 cattle had died, thus prompting the cattlemen to appeal to the Secretariat of Commerce for permission to export livestock to the United States. He said that the permission had not yet been received and that, "instead of helping us, they are hindering us still more." The cattlemen's leader added that the government had sent three DC-3 planes to seed the clouds with silver iodide, but noted that "the air force planes are too old to do this job." He also remarked that "the pilots, who were military, said that there was not enough time to try to make it rain, and that they would return later." [Text] [Nuevo Laredo EL DIARIO DE NUEVO LAREDO in Spanish 2 Jul 80 p 1] 2909

MINING INDUSTRY THREATENED--Nueva Rosita, Coahuila--Under a fiery sun beating down on this settlement, the correspondent from EL DIARIO, a newspaper that is always up to date in its details, was informed today that the drought cycle, or rain shortage, estimated as occurring every 7 years, which has just started, could cause a partial standstill in the Nueva Rosita mining industry. We were told, as a depressing announcement, that the management of the Mexican Mining Industrial Company, Inc., now has information to the effect that the "El Potrero" spring, located in the Muzquiz Sierra, which had been supplying water to two units that the ASARCO multinational company has here, is almost completely dry. This portends a gloomy industrial, economic and social future, because it will cause an inevitable wage readjustment for IMMSA workers associated with Section 14 and numbering 1,800, bringing about a constant decline in their wages. [Text] [Piedras Negras EL DIARIO DE PIEDRAS NEGRAS in Spanish 2 Jul 80 Sec A p 3] 2909

JUAREZ VALLEY STILL DRY--The pluviometric stations in the No 09 irrigation district indicate that the recent rainfall was recorded only in the urban area of this town, and not a drop has fallen on the Juarez Valley. Engineer Carlos Gustavo Mass Ostria, chief of the No 09 irrigation district, made the foregoing remark when it noted that the Ciudad Juarez pluviometric station had recorded precipitation amounting to 16.1 millimeters last Tuesday, when it rained. The Sauzal station registered 0.0; and the San Agustin, 0.1; while the amounts recorded in Praxedis and Caseta were immeasurable. The information supplied by the pluviometric stations is for statistical purposes, because the irrigation district is suppliedwith water received from the United States on the basis of the International Water Treaty. The official confirmed the fact that there has been no rain anywhere in the entire Juarez Valley, and that only partial cloudiness has been observed during the past few days. [Text] [Ciudad Juarez EL FRONTERIZO in Spanish 12 Jul 80 p 1] 2909

DAMAGE IN SONORA DESCRIBED--Hermosillo, Sonora, 3 Jul --The drought which has struck the state is continuing (the worst in the last 30 years), and, to date, it has caused: temperatures of up to 50 degrees centigrade in the shade; 50,000 cattle dead (official report); 250,000 hectares of agricultural land idle; reservoirs at 25 percent of their capacity; thousands dehydrated and with sunstroke; and over a billion pesos spent by cattlemen, all of which entails billions of pesos in losses. Engineer Martin Loperena, head of agricultural and livestock development for the state government, estimates that 50,000 head of cattle have died of thirst or hunger, because of the lack of forage and water. Jesus Ancheta Sanchez, head of the Sonora Regional Cattlemen's Union, claimed that the current drought, the worst in 30 years for the livestock industry, is causing the deaths of from 150 to 200 animals per day, and has cost a billion pesos. In a joint effort to reduce the fatality rate, the government and the cattlemen have distributed 32,000 tons of feed in the various cattle-raising areas. Ancheta Sanchez said that, "added to the burden of the drought, the cattlemen are also having to worry about shipping meat to the Federal District." [Text] [Nuevo Laredo EL DIARIO DE NUEVO LAREDO in Spanish 4 Jul 80 p 1] 2909

WATER TABLE STATUS EXPLAINED--Because of the terrible drought that has struck the region, the levels of several of the town's wells for water supply have dropped, although the JMAS [Municipal Water and Sanitation Board] officially claims that the problem is by no means critical. The head of the JMAS, engineer Nicolas Kosturakis Garcia, described the reduction in the water table owing to the prolonged lack of rainfall as logical and natural. In some wells, the pumping systems have had to be lowered to deeper levels in order to extract the vital fluid, when the current levels of the sources of supply dropped. Kosturakis Garcia was of the opinion that the wells would return to their normal levels as soon as we have rain, and hence he claimed that these reductions were not critical, but rather temporary. It should be added that the repumping of water during the current season has been constant, in order to meet the great demand for the crucial element. As a natural result, the levels of the supply sources have declined, but not to an alarming extent. He gave as an example the fact that, in some wells, the levels may drop 1 or 2 meters, and in such instances, the pumping systems are taken down to greater depths. [Text] [Ciudad Juarez EL FRONTERIZO in Spanish 8 Jul 80 p 1] 2909

BABICORA SEEN SERIOUSLY AFFECTED--The lack of rainfall in the state and the restriction an suspension of export quotas have caused thousands of head of cattle to be in danger of perishing for lack of forage; at the same time, the drought has affected the crops covering 600,000 hectares in the stormy weather crop areas of upper and lower Babicora. The foregoing statement was made by the acting senator, engineer Federico Estrada Meraz, head of the National Association of Small Property Owners and of the Cotton Producers Union. Engineer Estrada Meraz noted that, with the export quotas limited, the cattle for marketing abroad have remained on the cattle ranches and have consumed the forage which would have fed thousands of head of livestock. The status of the cattle industry in the state is serious, because there has been a considerable delay in the rainfall. It is feared that, if it does not rain, the situation will become more complicated, to the detriment of the cattlemen. In commenting on the situation in the countryside, he said that the drought has seriously affected the stormy weather crop areas, especially those located in upper and lower Babicora, where there are 600,000 hectares on which corn, beans, oats and potatoes are grown. Moreover, in view of the situation that prevails in the rural areas because of the lack of rain, the federal government has established a program of farmer solidarity, to insure jobs for the people in the countryside. [Excerpt] [Ciudad Juarez EL FRONTERIZO in Spanish 7 Jul 80 Sec B pp 1, 2] 2909

INTERNATIONAL DAM DEPENDENCE CITED--According to the International Boundary and Water Commission, the month of July is not at all promising: The statistics recorded by that entity for the past 122 years or more show an average of 34 millimeters of rain. Engineer Oscar Builbot, head of the Commission (CILA), described much of the country's border region as a semidesert zone, where the rainfall is not abundant and the temperatures exceed 40 degrees centigrade. This causes the countryside to remain in a state of poverty insofar as agriculture is concerned, except for the land under irrigation from reservoirs or rivers. Engineer Guilbot stated that, for example, the La Amistad and La Falcon international dams provided the necessary irrigation for all the land within the border strip, while others, such as the Venustiano Carranza and the Marte R. Gomez, irrigate very extensive areas in the Anahuac region of Nuevo Leon, and the Camargo region of Tamaulipas. These are dams with large storage capacities which, while meeting the needs of agriculture, also insure the supply to the Mexican and United States border towns, in conjunction with the two international ones. [Text] [Nuevo Laredo EL MANANA in Spanish 7 Jul 80 Sec B p 1] 2909

CSO: 5000

JORDAN

REFORESTATION OF 20,000 DONUMS PLANNED FOR THIS YEAR

Amman AL-RA'Y in Arabic 12 Jun 80 p 6

[Article: "Reforestation of 20,000 Donums in Various Areas and Production of 5.1 Million Forest Seedlings"]

[Text] The Ministry of Agriculture has announced its reforestation plan for the coming season within the framework of its overall 5-year plan.

Dr 'Abd-al-Rahim al-Talli, the Agriculture Ministry's director of reforestation, said that the plan for the coming year includes reforestation of 20,000 donums distributed as follows:

Irbid: 2,000 donums; 'Ajlun: 1,000 donums; Jarash: 2,500 donums; al-Mafrqa: 2,000 donums; al-Zarqa': 2,500 donums; 'Amman: 1,000 donums; al-Balqa': 2,500 donums; Ma'daba: 1,000 donums; al-Tefilah: 1,250 donums; Ma'an: 750 donums; and 2,000 donums is grazing land distributed among stations in various areas of the kingdom.

Dr al'Talli said that the total area planted in forest during the 1979-80 season was 17,686 donums. Some 183,468 forest seedlings were planted in this area. In addition, 8,558 donums was replanted during the same season.

Concerning the ministry's plan for the production of forest seedlings, Dr al-Talli stated that 3,297,576 forest seedlings were produced last season. Some 1,832,468 of these were planted by the Agriculture Ministry while the remainder were distributed free for planting to citizens and government and private organizations in order to help renew timber resources in Jordan as a part of the Agriculture Ministry's plan.

With regard to the forest seedling plan for the 1980-81 season, Dr al-Talli said that the plan will include production of 5.1 million seedlings alloted as follows:

Dayr 'Ala Nursery: 950,000 seedlings; 'Ayn Jamla: 650,000 seedlings; al-Dhalil: 500,000 seedlings; Yajuz: 1 million seedlings; al-Sula: 450,000 seedlings; al-Karak: 350,000 seedlings; al-Tafilah: 350,000 seedlings; and al-Shubak: 400,000 seedlings. Some of these seedlings will be planted by the Agriculture Ministry in designated reforestation areas and the rest will be distributed for planting without charge to citizens and government and private organizations.

8591
CSO: 4802

BRIEFS

MA'AN'S NEW WATER SYSTEM--The general director of the Drinking Water Agency, Engineer Sa'id Binu, announced that bids were opened yesterday regarding the installation of a new drinking water system for the city of Ma'an. Engineer Binu stated that the planned system will take the place of the present system and will cost 94,000 dinars. Implementation of the project will begin 1 month from now and will take 8 months to complete. [Text] [Amman AL-RA'Y in Arabic 12 Jun 80 p 2] 8591

CSO: 4802

DDT THREATENS WILDLIFE

Salisbury THE HERALD in English 6 Aug 80 p 7

[Article by Sheila White]

[Text] The biggest ecological challenge facing this country was the continued indiscriminate use of DDT pesticide, a Department of National Parks and Wild Life Management warden has warned.

Welcoming moves to replace DDT with a more expensive but less hazardous pesticide, the provincial warden for Mashonaland South, Mr Ron Thomson, said during an interview that certain species of birds were facing extinction.

"Most seriously threatened is the fish eagle, the fishing owl, the peregrine and lanner falcons, the black sparrowhawk, all the other smaller sparrowhawks and small goshawks, the herons, and the cormorants," he said.

Not only were the lives of adult birds being lost but even more devastating was the interference caused to the breeding cycle by the pesticide, "which is freely and cheaply available even on the shelves of supermarkets".

Departmental files had recorded the case reported by a Glendale man, Mr Barry Brooke, who, to eradicate an army worm infestation, had applied DDT. A flock of abdims storks arrived to feast on the worms and 64 were found dead as a result.

But DDT does not always kill directly. More insidious is the way the high Zimbabwe temperatures, ultra-violet rays, and metals in the soil, catalyse and break it into another chemical--DDE--the real killer.

Recent research had proved that when the DDE content of a bird's egg reached a certain level the population started to experience reproductive failure.

"Two samples of peregrine eggs which we examined recently showed a content of more than 62 parts per million while fish eagle eggs have provided evidence of DDE levels of anywhere up to three times the threshold at which the American bald eagle population started to decline," said Mr Thomson.

Describing Kariba as "a big sump" for all the rivers in the surrounding cotton-growing areas where DDT was used extensively, he said that once the DDE entered a water body the bottom of the food chain--microscopic animals--living organisms and algae--were immediately affected.

"Because it is a highly fat-soluble chemical, it is readily absorbed by the microscopic animals and stored in their own fat cells. The smaller fishes who survive on these microscopic animals are then contaminated.

"They in turn are eaten by the larger fish--with the DDE accumulating in their fat reserves until they are then eaten perhaps by a tiger fish. Finally the fish eagle may eat the tiger fish--so the pyramid of destruction grows."

Breeding

Strangely enough, the eagle may remain unaffected until the bird utilises its own fat reserves--perhaps while recovering from damage and not able to hunt in the normal way, or during the breeding cycle.

"When the bird starts using his own body fat then the DDE in the blood stream is released with sometimes fatal results."

Hormonal side effects may decide the female against remaining on the nest to hatch her young. Another by-product of DDE poisoning is thin-shelled eggs which are all too often crushed during incumbation, or result in the embryo dying of dehydration.

Young birds die, too, just before hatching when the yolk--the food reserve--is absorbed and could contain a lethal quantity of DDE.

Encouragement is being given to the African peasant farmer towards growing cotton. Because of its ease of application and reputed "low mammalian toxicity" DDT is the recommended pesticide.

"What we will be doing is subjecting our peasant population to risks since we don't know--because it is difficult to prove--the relationship between DDT and adverse clinical symptoms in man. But there is prima facie evidence that such a relationship may be possible."

Mr Thomson said it was estimated that up to 800 tonnes a year were used in agricultural and huge quantities in tsetse and malaria control.

"We are extremely concerned that wildlife is in danger." He thought the continued use of DDT would make many of the susceptible bird species extinct in Zimbabwe in between 10 and 15 years at the present rate of application. "If this is increased the disappearance of these birds will occur sooner."

To preserve falcons, at any rate, Mr Thomson has two in captivity outside his Salisbury headquarters office in the hope that they will breed.

"At least if they become extinct in this country we will have a gene pool left."

In America some U. S. $350 000 is being spent to maintain 76 pairs of falcons towards reintroducing them to the wilds. There are none left in the eastern part of the continent. As bird-eating hawks they are particularly susceptible to DDT poisoning.

Both America and South Africa have banned DDT.

CSO: 5000

ITALY

BIOLOGICAL EFFECTS OF NON-IONIZING ELECTROMAGNETIC RADIATION

Bio-electromagnetic Research

Milan ALTA FREQUENZA in English Mar-Apr 80 pp 47-54

[Article by Paolo Bernardi, Istituto di Elettronica, Universita di Roma, and Guglielmo D'Ambrosio, Istituto Elettrotecnico, Universita di Napoli: "Bio-electromagnetic Research: Review of Some Important Aspects"]

[Text] *Abstract.* The growing use of equipment and systems which irradiate electromagnetic (EM) energy has increased the importance of the study of the biological effects produced by interaction of EM waves with humans.

This paper surveys the principal areas of research which have been developed in various countries of the world over the recent years, the problems still to be solved, and the most important results obtained.

Particular attention is given to the present activity and the progress of research in Italy.

1. INTRODUCTION

In recent years the interest in the biological effects of Non-ionizing Radiation (NIR) has been in continual development all over the world.

There are many factors which have determined this growing interest. Above all the awareness of these effects is essential in assessing potential electromagnetic (EM) health hazards and in protecting both occupationally exposed operators and the general public from the pollution produced by the increasing use of EM systems.

The technological development has in fact introduced, together with the more traditional uses of EM waves in radio and telecommunication systems for civil and military applications and with the radar techniques developed from the end of the 2nd World War, new uses of EM emitting equipment. Today this equipment is spreading [1] into the industrial processes of heating, drying, sizing and melting of various types of materials, in diagnostic and therapeutic medical applications, in domestic uses such as cooking food and surveillance, in satellite telecommunications, in radioastronomy and radiometeorology.

In addition, new applications of EM techniques are in the development stage, such as cancer treatment by hyperthermia [2], Radio-Frequency treatments in agriculture [3], insect control without chemical contamination [4], high-power microwave beam transmission [5,6].

The systems listed have not only expanded in number, but also in the levels of power produced: there are systems in operation today which work with powers of the order of thousands of megawatts [6].

Also in the field of the conventional transmission lines of electric energy (at 50 or 60 Hz), the modern tendency to utilize increasingly higher voltages (1000 and 1500 kV) creates the problem of a more detailed knowledge of the interaction phenomena in this frequency range [7].

These circumstances, together with a renewed interest of society in problems of an ecological character and the awareness of the necessity to suitably control the consequences of technological development have, on one side, developed scientific interest in the problem and, on the other, have induced the authorities of various countries to issue laws or regulations which establish levels which are not to be exceeded if working activity is to be rendered safe in the presence of radiating equipment, and the health of the public in general is to be safeguarded.

As far as the scientific aspect is concerned, research has been particularly developed and diffused since the end of the sixties. The results of this research were discussed in numerous international congresses and published in scientific literature.

Among the most recent and important congresses we can quote those on "Biological Effects and Health Hazard of Microwave Radiation", Warsaw, October 1973 [8]; the New York Academy of Science's Conference on "Biological Effects of Nonionizing Radiation", New York, February 1974 [9]; the USNC/URSI Annual Meeting, Amherst, October 1976 [10]; the Bioelectromagnetics Symposium, Seattle, June 1979 [11], the International Microwave Power Institute (IMPI) Annual Symposium series.

With regard to the scientific literature, a very extensive bibliography is included in some recent volumes [7,14]. A selected survey of the work carried out in many countries during these past years has been put out by the International Union of Radio Science (URSI) who has devoted a chapter to "Bioeffects of Electromagnetic Waves" in the Review of Radio Science 1975-1977 [15]. In addition, the Italian contributions during the same period (1975-77) have been collected by the URSI Italian National Committee in a bibliography presently in press [16].

In the field of the formulation of regulations for the protection of people exposed to NIR, some initiatives at a European level are presently being carried out.

The World Health Organization is conducting a research program in this field in its European Regional Office. The long term objectives of this program are to assist governments in protecting both occupationally exposed operators and the general public from adverse effects of NIR. The short-term objectives are to promote studies on the health effects of various types of NIR and to review existing laws and regulations on the subject, making proposals for their improvement. One of the objectives of this program is to publish, in 1980, a "Manual on Nonionizing Radiation Protection" of which some chapters are already available on certain frequency ranges. An outline of the manual, together with a list of the chapters already published is given in [16].

The Commission of the European Communities is at present developing a program proposal on the Biological Effects of NIR. Four principal areas of research have been defined and corresponding working groups have been established: optical radiation with emphasis on ultraviolet radiation and lasers; nonoptical electromagnetic radiation including microwaves, radiofrequencies and extremely low frequencies; static fields; and ultrasound.

Italy, besides participating in the aforesaid activities, has recently taken up two initiatives. The first concerns the constitution within the Consiglio Nazionale delle Ricerche (CNR) of a Commission with the task of preparing a feasibility study for a finalized project on "elaboration of a set of regulations for protecting people exposed to nonionizing electromagnetic fields". The second concerns an hypothesis for a set of regulations in the field of protection from radiofrequency and microwave radiations, elaborated by the Radiation Laboratory of the Istituto Superiore di Sanità [17].

Coming back to the scientific aspect of bioelectromagnetic research, it must be underlined that numerous studies have shown that the absorption of electromagnetic energy by tissues can produce, besides the more easily quantifiable thermal effects due to the dissipation of this energy, also biological effects, commonly classified as non-thermal, directly associated to the EM field induced in tissues. For example, mechanisms of this type can be held to be responsible for alterations in the development and growth processes of organisms [12]. Some researchers have put forward the hypothesis of possible cumulative effects produced in organisms exposed to NIR, even if there is still no complete agreement among scientists on this point. Other open questions concern the hypotheses that electromagnetic radiations can alter the nature, reactions of the organism to other types of stimuli or that they can produce genetic alterations [13].

In general, as demonstrated in the literature mentioned, it can be observed that bioelectromagnetic research falls into the two large sectors of dosimetry, oriented to the determination, with theoretical and experimental methods, of the energy absorbed by the living subject, and in that concerning the study of biological effects, at a level of elementary constituents such as macromolecules and cells or, more often, at a level of physiopathological reactions in complex organisms. Among the numerous observations on this latter type we can point out those regarding sensorial perception and visual alterations, the central nervous system and its behavior, the neuroendocrine system and the cardiovascular one, hematology and immunology.

In the present work, after the panorama given in this paragraph on the origin and growth of interest in the matter, some aspects of this wide subject are pinpointed.

In particular, in paragraph 2, the results of observation of some specific effects are examined and a general type of behaviour of biological systems submitted to EM radiation is evidenced.

In paragraph 3 the problems of dosimetry are discussed, with emphasis on the mutual interactions between sources, environment, and biological object, and then (paragraph 4) a brief review of the bioelectromagnetic research presently being carried out in Italy concludes the paper.

2. BIOLOGICAL EFFECTS

Many experimental data have been collected, especially in recent years, about biological effects of EM waves, but the attention of researchers was devoted mainly to unmodulated radiation and to particular frequency ranges, if not to specific single frequencies (2.45 GHz) [18]. So it has to be pointed out that, despite the large amount of observations, a substantial lack of knowledge remains about frequency-dependent phenomena (resonances) and modulation effects (*).

Another point, in our opinion, to be investigated more throughly is that concerning the cumulative (or not) character of the various bioelectromagnetic effects. When some of them appear to depend on the absorbed energy amount, regardless of its time distribution (power), one may say that the biological effects observed, as a function of the integral of the absorbed power, exhibit a cumulative character. In some cases, quoted below, the above behaviour was demonstrated, but in others the biological system exhibit recovery aptitudes acting against the integrating one [20].

In general, bioelectromagnetic interaction may be viewed as a process involving different logically subsequent stages [21] (Fig.1). The distribution of field and absorbed power into the biological object can be considered as the response of the first stage of the system; the study of this stage is just a matter of engineering. In this area valuable results were obtained, also taking into account the influence of the environment and the coupling between sources and the exposed object [22]. Given the internal field distribution, various thermal and non-thermal elementary effects occur locally (second stage); but here, besides heat production, very little is known about other biophysical processes [23]. In any case the biological system reacts to local elementary effects with a series of physiopatological responses (third stage).

As a matter of fact, due to the ignorance concerning the second stage of the logical chain outlined, the "biological effects", final output of the system, cannot be related to the (unknown) input of the third stage; they could be related, then, to the internal field distribution (second stage input), but in most literature they are simply presented together with the exposure conditions (essentially the first stage input) or, at most, with the entire body's specific absorbed power (something midway between the first stage input and output) [18]. In this situation, due to the complex interaction chain between exposure parameters and final biological effects, the experimental findings generally cannot be related strictly to the primary input nor is it an easy matter to place them in a theoretical frame.

Nevertheless, when there is a great amount of data collected about the same phenomenon, it is possible to draw some "external characteristics" of the biological system, with regard to the observed effect. In such cases resonable predictions can be made and some insight can also be gained.

Among the many biological effects observed (regarding neurology, endocrinology, hematology, and other medical sciences) reviewed in several excellent papers (see for istance [15,20,24]), we want

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(*) Some results concerning experiments with pulsed radiation are reported in this issue [19].

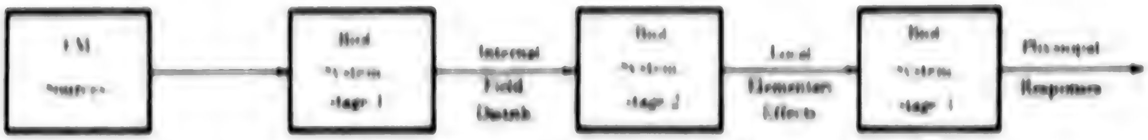

Fig.1 – Three stage interaction chain.

to recall here the influence of radiation on organisms at the embrionic level, on reproductive organs, and on the lens of the eye. These subjects were extensively studied and rather precise overall relations between field parameters and observed phenomena were established.

The exposure of pregnant female rats to radiations at various frequencies [25,26] produced severe malformations in fetuses like exencephaly, facial aplasia, anophtalmia, and various heart, kidney, and liver anomalies; but no general rule or conclusion could be drawn from these experiments [25]. Much more precise indications were obtained from microwave (2.45 GHz) exposure of chick embryos [27,28]. Besides a general inhibitory effect on the growth, it was observed that, after irradiation, "cellular proliferation continued but differentiation did not; so that the development of structures, which had not begun to differentiate before irradiation, was suppressed". Another interesting finding was that certain organ rudiments were removed from embryos which had been exposed to a malforming quantity of microwave radiation and were transplanted to non irradiated embryos, they developed normally. This indicates that in development of local anomalies the whole biological system may be involved. Such results were obtained both at high power levels and at low power levels. In the latter case the temperature of the embryo increased only a few degrees. The same heating (rise, level, and duration) induced by other means had no similar effects. This suggests that a non-thermal mechanism is responsible.

From results pertaining to various power levels and exposure durations some other observations can be added.

- At medium power levels ([28], table III) the onset of developmental anomalies (teratogenic effects) occur when a given absorbed energy amount (power, P, times exposure duration, Δt) is reached. In this putatively non-thermal effects region, a cumulative behaviour is thus established, and on a (P,Δt) plane the threshold line is represented by a hyperbola PΔt = const. (Fig.2, solid line).
- At low power levels ([28], table IV) the biological system appears to be less sensitive, the same energy is not sufficient, and more exposure time is needed (Fig.2, dashed line). This behaviour is consistent with the hypothesis of a threshold power level found in other experiments [24], [28].

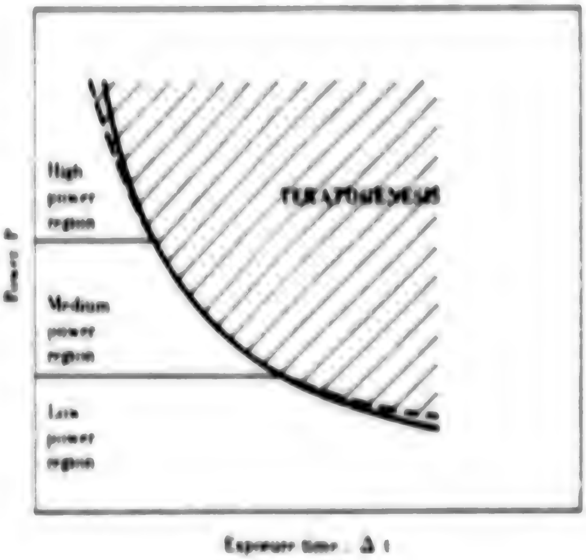

Fig.2 – Chick embryo teratogenesis threshold; indicative sketch. Solid line: PΔt = const.

- At high power levels ([28], table I), on the contrary, the system appears more sensitive and the onset of teratogenesis occurs at a lower time (and energy) than predicted by the hyperbolic law (Fig.2, dashed line). Given the temperature rises observed at these power levels, a thermal effect, acting either concomitantly or synergistically with the non-thermal ones, may be held as responsible.

A quite similar picture can be drawn from experiments carried out at an entomological level. A review of teratogenic effects of microwaves on Tenebrio molitor, together with new results, is given elsewhere in this issue [19].

As regards the effects of NIR on reproductive organs, it can be said that no evidence of changes in human fertility due to microwave exposure was found [20], but many experiments have been performed on laboratory animals and damage to the germinal epithelium of seminiferous tubules was histologically observed. From experiments on dog testes some power-time threshold characteristics could be drawn; a behaviour similar to that occurring in microwave

-induced teratogenic phenomena was established and, in particular, a threshold power level was evidenced [24].

As regards the development of opacities (cataracts) in the lens following EM exposure, extensive research was devoted to this subject, and many experiments were carried out on rabbits and dogs at various frequencies in the microwave range [20]. At a given frequency, with a given exposure technique, again a safety power level was found, at which no effect appeared regardless of exposure duration, and a power-time behaviour could be outlined [24]; as in the case of teratogenesis, in a certain range the effect appeared to depend on the integral energy dose (cumulativity).

Some common features emerge from the above quoted experiments on different biological objects. The power-time threshold characteristics, shown with details in the case of teratogenic phenomena, appear to reflect a general behaviour, and can be assumed at least as a working hypothesis when studying various bioelectromagnetic interactions: a sub-threshold and low-power weak-effect region, a medium-power region (where the essentially non-thermal effects depend strictly on the absorbed energy), and high-power strong-effects region, where the thermal injury plays an increasing role, can be assumed as a reference standard picture for experimental findings in various bioelectromagnetic researches [19].

3. THEORETICAL AND EXPERIMENTAL DOSIMETRY

The interaction of EM fields with biological systems produces effects which can be classified and evaluated under different points of view according to the organizational level of the living system considered (molecular or cellular, single organ, entire organism).

However, at the present state of knowledge, whatever the organizational level considered, it can be assumed [14] that the electromagnetic energy absorption constitutes the response of the first stage of the interaction chain shown in Fig.1.

This effect, called by Czerski the "primary interaction", has therefore a fundamental importance in the study of interaction and many researches, both theoretical and experimental, are going on for quantitatively establishing the link between the sources of the EM field and the energy absorbed by tissues. These researches, generally classified as "dosimetric" researches, can be considered as not indispensable for the purpose of appraising physiopathological responses of an irra living system, if the pragmatic approach which directly connects (Fig.1) the cause (the EM sources) with the effects (physiological and/or pathological responses), is held to be sufficient.

Such an approach has however doubtful aspects both from a biological and an electromagnetic viewpoint. On one hand, the knowledge of the power absorbed is indispensable for research and for understanding the basic mechanism of interaction. For instance, one of the major problems in this area, as has been previously mentioned, is that at the moment we are not always able to evaluate if absorbed power is purely dissipated or if other field effects may also influence biological systems.

From an electromagnetic point of view, it does not always seem possible to consider a radiating source as an impressed quantity, that is independent of the system with which it interacts, as is shown in the case illustrated in Fig.1.

Very often the interaction must be schematized in the more general form shown in Fig.3a in which the environment (other bodies or scattering surfaces placed near the system under examination) and the irradiated biological system influence each other and both interact with the sources [30]. In this case (Fig.3a) it does not seem easy to establish a link between the biological effect produced and a characteristic quantity of the EM sources, whilst it is always possible, in principle, to establish a link between the biological effect and the internal field distribution.

In some cases the scheme in Fig.3a can be simplified: for instance when the reaction of the biological system on the sources and on the environment can be neglected (Fig.3b); in this case the exposure conditions are completely defined in terms of the EM field incident on the irradiated body, that is the field produced by the sources with the given environment in the region in which the body is situated, but in absence of the body itself.

Very often, the research conducted up to now has been referred to particular exposure conditions, that is to conditions in which the bodies are situated in the far-field of the sources and are therefore irradiated by EM plane waves (Fig.3c). With reference to these particular conditions, an "exposure-rate" is defined, which expresses the EM sources in terms of the power density incident on the body.

In the case of irradiation of bodies situated in the near-field of the sources, the "exposure-rate" loses significance and other parameters must be adopted to characterize the exposure conditions. Problems of this kind have been faced

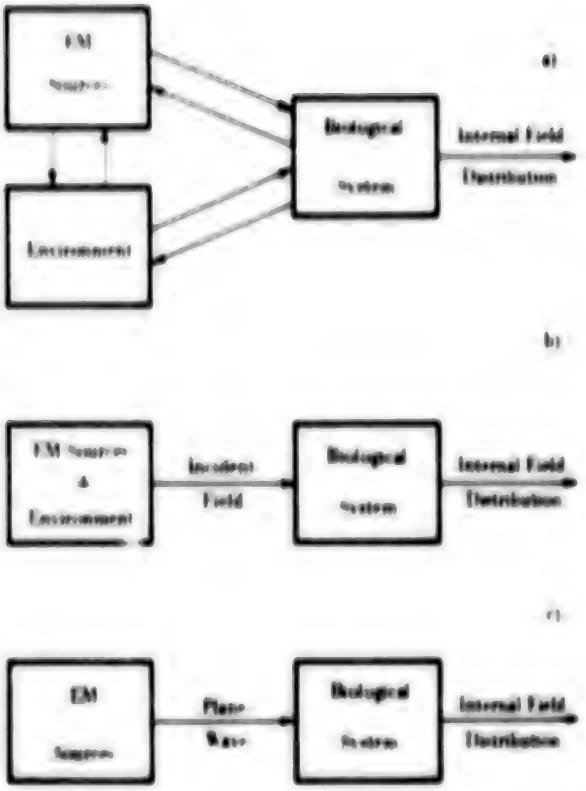

Fig.3 - Types of interaction conditions.

for bodies exposed to fields produced by apertures [31], by electric and magnetic dipoles [32,33], and by multimodal cavities [34,63].

The dose-rate concept (power absorbed per unit volume or mass) directly links the biological effect to the power absorbed within the irradiated body. Standard dose-rates are usually defined both as "integral dose-rate", that is the power absorbed by the entire biological body, and as "dose-rate distribution", that is the power absorbed per unit volume (or mass) at a location in the biological body [31].

In addition to the exposure safety standard, the concept of "emission standard" has been introduced into the study of electromagnetic interaction [34]. This concept has been used to characterize particular exposure conditions, different from those defined by the exposure-rate, as occurs for example in the case of humans exposed to leakage of typical sources (particularly microwave ovens).

The theoretical research carried out in the dosimetric field over the last years has been considerable. Various types of geometric models (sphere, cylinder, spheroid and ellipsoid, homogeneous and stratified) of man and his organs have been examined and, by means of various methodologies, the relation between absorbed power (total and distributed) and incident power has been calculated. A review of the most recent work carried out in this field is included in [18].

It can be observed that the greatest part of the dosimetric research neglects the effects of the environment on the interaction, that is it neglects the mutual interaction between sources, environment and irradiated bodies (Fig.3a). A different approach is faced in a work which appears in this issue in which, using a simplified model, the power absorbed by an irradiated object is found, taking into account the reciprocal influences of source, environment and biological body [22].

Experimental research in the dosimetric field has as an objective the quantification of the EM field induced in subjects exposed to radiations, and requires that both the fields in the environment and within the tissues be measured. Measurements of external electromagnetic fields for general exposure conditions, that is in the presence of uncharacterized electromagnetic fields, multipath components and reactive near-field components, have been conducted with isotropic spatial response probes. This was obtained by arranging three dipoles (electric or magnetic) in an orthogonal array, finding the signal of each dipole by a detector with square-law response and adding up the three signals found. With this technique the result is a signal proportional to the energy density (electric or magnetic) of the incident field [35,36]. Problems connected to the precision of these measurements, such as: low scattering characteristics of probes, types of detectors, high-impedance leads, are discussed in [37].

Measurements of the field distribution and associated power absorption within biological specimens present a series of complicated problems. Since the electric field probes must be inserted directly into the body, they must have an appropriate shape so as not to disturb the vital function of the organ considered. From an electromagnetic viewpoint, besides the need for a good spatial resolution, there are the problems of field perturbation caused by probes and by leads used to conduct the signal outside the body, and that of the effects on the measurements caused by a medium with spatially inhomogeneous electrical constitutive parameters.

Techniques for overcoming these difficulties have been recently examined. Measurement techniques for antennas in dissipative media are discussed in [38]; in this paper an experimental environment large enough to approximate an infinite dissipative medium is considered. The conditions that must be satisfied if electric field probes in a dissipative medium are to have a response independent of the electrical constitutive parameters are discussed in [39], whilst a study of various types of electric probes with a particular geometry (electrically short, resonant, bare or insulated) is given in [40].

Thermal probes and thermography have been used to determine average absorbed power densities and electric fields within biological specimens [41,43]. A review of thermographic techniques for the measurement of absorbed power in phantom tissue models and animal carcasses is given in [44].

Finally, a technique for determining the electric field within a biological sample, based on a remote-sensing method, has been discussed [45]. The method consists of imbedding an isolated diode in the biological sample and assessing the local field by measuring the amplitudes of the intermodulation spectrum re-radiated by the diode exposed to a dual-frequency illumination.

4. BIOELECTROMAGNETIC RESEARCH IN ITALY

After the pioneer's work that can be reckoned back to the Galvani's experiments of about two centuries ago on frogs (1791) and more recently to the Cazzamalli's observations about radio waves and brain activity interactions (1925)[47], a sporadic activity was initiated before the second world war. In recent years, related to the generally growing interest in bioelectromagnetic interaction phenomena, a coordinated work has been undertaken in various Universities and Research Institutes, giving rise to a number of contributions, listed in [46].

Besides the more traditional work in the optical region of the nonionizing radiations spectrum, the research activity on the biological effects of the electromagnetic fields, from ELF up to millimetric waves, has developed in different directions which, however, can be framed according to the interaction scheme of Section 2 (Fig.1).

Theoretical work pertaining to the first stage (from electromagnetic sources to field distribution inside the biological object) is being carried out at the Universities of Bari (coupling between sources and exposed subjects [62]) and Rome (influence of the environment on power deposition in man [22,56], and temperature distribution in irradiated biological bodies [48]. The attention devoted at the University of Florence to the modelling of the human thorax, for diagnostic purposes can be considered in the same area [49]. Field measurement problems are being studied at the Istituto di Ricerca sulle Onde Elettromagnetiche (Florence)[50], at the Istituto Superiore di Sanità (Rome)[51], at the Istituto Elettrotecnico Nazionale Galileo Ferraris (Turin)[52], and at Aeritalia (Turin)[53], while researches on the whole body exposure and dosimetry techniques are being done at the University of Naples [54] and microwave spectroscopy of biological substances is being carried out at the Laboratorio per i Circuiti Elettronici (Genoa)[55].

In connection with the second stage of the scheme of Fig.1 theoretical and experimental works at the Universities of Genoa [57] and Palermo [58] are being carried out.

Observation of physiopathological responses of living systems (final output in Fig.1) is the basis of researches carried out at the Universities of Florence (blood sedimentation rate [58]), Naples (insect teratogenesis [59]), and Pavia (radio frequency-induced arrhythmia [60]); at the Istituto di Ricerca sulle Onde Elettromagnetiche (enzimatic activity [61]); and at the Istituto Superiore di Sanità (iron metabolism in animals [64]). Among these must be quoted the researches done in the ELF range by the Ente Nazionale per l'Energia Elettrica (ENEL)[65].

This sketch, although not complete, is intended to give an idea of the various trends of bioelectromagnetic research in Italy.

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Electrically-shielded Enclosure Hazards

Milan ALTA FREQUENZA in English Mar-Apr 80 pp 55-60

[Article by Paolo Bernardi, Guglielmo D'Inzeo, Franco Giannini, Roberto Sorrentino, Istituto di Elettronica, Universita di Roma: "Quantifying the Hazard of Field-Man Interaction in Electrically Shielded Enclosures"]

[Text] *Abstract:* Both the average value and the distribution of the specific absorption rate (SAR) are calculated for biological tissue irradiated in an electrically shielded enclosure. In this case the power radiated by the source and the power absorbed by the body depend on the positions of the source and the body with respect to the enclosure; consequently, the exposure-rate concept cannot be used to quantify the hazard.

A new method is therefore proposed to evaluate the hazard of the interaction inside an enclosure. The method refers the power absorbed by the body to that absorbed in a reference structure. Calculations have been made in the frequency range of 100 MHz, in which maximum power absorption occurs for humans; furthermore the wavelenghts in this frequency range are comparable with the dimensions of civil or industrial enclosures where electromagnetic (EM) sources are normally installed . Finally, some parameters have been introduced to evaluate the hazard when the interaction takes place within a shielded enclosure.

1. INTRODUCTION

The most relevant parameter of the hazard of the interaction between electromagnetic (EM) fields and biological bodies seems to be the Specific Absorption Rate (SAR: power absorbed per unit mass of the body). This quantity is related univocally to the power density incident on the body only when the latter is in free-space and a uniform plane wave is incident on it (plane-wave, free-space irradiation conditions). For a given body, the relationship between SAR and incident power density is only dependent on the frequency and the field polarization with respect to the body orientation. Such a relationship makes it possible to use extrapolation methods [1] for comparing different radiating fields producing the same average SAR in different bodies (e.g., an animal and a human). Many studies have dealt with the problem of relating the SAR to the incident power density [1,3,8,10] and the quantification itself of the hazard is given in terms of the incident power density (mW cm^{-2}).

In pratical cases, however, bodies are exposed to more complex EM field, e.g. to the near field of apertures and/or in the presence of reflecting surfaces. In such cases, it is always possible to define the incident EM field (field in the absence of the body) as well as the incident power flux, but the relation between SAR and incident power flux not only depends on a great number of parameters other than the frequency and the field polarization, but is often also indeterminate (consider a body exposed to a purely standing wave). As in the usual irradiation conditions, when, inside an enclosure, workers are exposed to the EM field of industrial heating apparatus, the only meaningful parameter apt to quantify the hazard is the SAR.

The scope of this work is to study a model which, besides stressing the inadequacy of the incident power flux concept, makes it possible to quantify the SAR for bodies irradiated inside enclosures. Though simplified, the EM model adopted stresses the main features of the interaction in enclosures. Moreover, to deal with the problem of quantifying the hazard, in view of the many parameters on which the interaction depends, a suitable reference structure is introduced. This structure is such that, under proper conditions, the SAR of a body is the same wherever it is placed inside it, regardless of the distance from the source. Hence it is possible to introduce suitable coefficients which allow the hazard of the actual conditions of interactions to be quantified in terms of the reference structure.

2. ELECTROMAGNETIC MODEL AND FIELD SOLUTION

The interaction between an EM source and a biological body, when both placed inside an enclosure with reflecting walls, is studied using the EM model sketched in Fig. 1. The source of the EM field is schematised by an impressed current density $\underline{J}_i = \underline{x}_0\ J_{ix}(x,z) + \underline{y}_0\ J_{iy}(x,z)$ laying in a plane transverse to the z-direction. For simplicity, the current source, as well as the whole structure, is supposed independent of the y-direction.

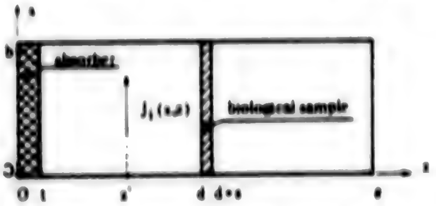


Fig. 1a - *Biological sample irradiated in an electrically shielded enclosure*

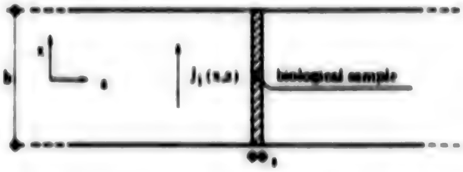


Fig. 1b - *Biological sample irradiated in the reference structure.*

The biological body is represented by a plane layer of homogeneous muscle tissue having a frequency dependent complex permittivity of the form

$$\epsilon_c = \epsilon_1 - j\epsilon_2 = \frac{\sigma}{j\omega\epsilon_0} + \epsilon_\infty + \sum_{i=1}^{2} \frac{a_i}{1 + j\omega\tau_i} \qquad (1)$$

where ϵ_0 is the vacuum dielectric constant, σ is the steady state conductivity of the biological tissue and ϵ_∞ is the permittivity at sufficiently high frequencies for the orientational polarization to have disappeared.

The above expression is an extension of the well known Debye dispersion formula for the complex permittivity of a lossy dieletric and allows, by suitably choosing the values of a_i and τ_i, a good approximation of the values ϵ_1, ϵ_2 of a muscle tissue in a frequency range two decades wide.

Table 1 gives the values of a_i and τ_i for the 5-500 MHz frequency range, together with a comparison between the values computed through (1) and those estimated from data published by Johnson et al. [1].

(*) Work partially supported by the Consiglio Nazionale delle Ricerche.

TABLE 1

$\sigma = 0.37$ S/m		$\varepsilon_\infty = 25$		
$\alpha_1 = 230$		$\tau_1 = 3.03\times10^{-8}$ sec		
$\alpha_2 = 74$		$\tau_2 = 2.10\times10^{-8}$ sec		
$\alpha_3 = 25$		$\tau_3 = 1.07\times10^{-10}$ sec		
f	ε_1		ε_2	
MHz	computed	literature	computed	literature
5	210	210	2167	2335
10	158	160	1116	1132
20	128	129	578	539
30	118	110	400	374
40	109	98	312	310
60	95	83	225	225
80	84	74	170	186
100	78	71	150	160
200	57	57	98	112
300	51	54	62	84
400	45	52	51	65
500	45	51	44	52

Finally, the room where the interaction takes place is represented by a cavity with perfectly conducting walls. The possibility has been considered of a dissipative dielectric slab set against the wall facing the source, in order to account for the imperfect conductivity of actual enclosures.

Once the model of Fig.1 has been established, the EM field in the structure can be calculated following the procedure indicated in [7].

We shall limit our attention, without basically changing the problem, to the EM field which is TM with respect to the z-direction; this means that we shall consider only the field radiated by the x component of the current exitation. Under this assumption, the only non-zero component of the magnetic field, H_y, is given by

$$H_y = \sum_{m=0}^{\infty} H_m(z) \cos \frac{m\pi}{b} x \qquad (2)$$

with

$$H_m(z) = \int_0^a G_m(z/z')J_m(z')dz' \qquad (3)$$

$$J_m(z') = \frac{\delta_m}{a} \int_0^a J_{ix}(x,z) \cos \frac{m\pi}{b} x \, dx \qquad (4)$$

$$\delta_m = \begin{cases} 1 & \text{for } m = 0 \\ 2 & \text{for } m \neq 0 \end{cases} .$$

$G_m(z/z')$ is the Green function of the structure. The non-zero E-field components, E_x, E_z, are then easily obtained through (2) and Maxwell's equations. The evaluation of the quantities which are relevant to the safety problem, such as the power radiated by the source, the SAR distribution and its average value is straightforward.

It should be noted that, for a given source, the SAR is a function of several parameters, such as the frequency, the size of the body model, the distance source-model, the positions of the source and of the model within the cavity, the dimensions of the cavity, and the characteristics of the absorbing layer.

Therefore, the evaluation of the hazard, when the interaction takes place in a shielded enclosure, appears to be very complicated even if a roughly simplified EM model is adopted.

To overcome this difficulty, it seems to be useful to define some quantities which characterize the hazard of the interaction in terms of a suitable reference structure such that SAR be independent of some of the above parameters.

Let us consider the guiding structure of Fig.1b, which is obtained from that of Fig.1a by eliminating any reflection from the walls at z=0 and z=a. Let us firstly suppose that the source can excite only one mode; in such a case it is easy to verify that, provided the frequency is greater than the cut-off frequency, the power absorbed inside the biological slab does not depend on the distance between the slab and the source. Consequently, the SAR for a given amplitude of current excitation is a function only of the frequency.

More in general, when the current distribution excites an infinite set of modes, the power absorbed at a given frequency will still be independent of the slab-source distance, provided this distance is sufficient to make the amplitude of the EM field due to the evanescent modes negligible. In other words the power absorbed within the tissue model placed in the reference structure of Fig.1b depends only on the frequency, provided any reactive coupling between the source and the slab is avoided.

Once the average power density absorbed in the reference structure has been calculated, the evaluation of the radiation hazard in actual conditions of the interaction, may obtained introducing the ratio:

$$r = \frac{\text{Average SAR in the actual structure}}{\text{Average SAR in the reference structure}}$$

where both the numerator and the denominator are calculated for the same current excitation.

The importance of evaluating the absorbed power in terms of a reference situation is that it allows any dosimetry in actual conditions of interaction to be reduced to the only one in the reference structure. In other words, once the hazard levels have been evaluated, theoretically or experimentally, for a given source in reference conditions, it is easy to deduce the hazard levels in actual conditions of interaction. The parameter "r" may therefore be regarded as a coefficient which accounts for the hazard increase (or decrease) due to enclosure, to the proximity of the source, and to the positions of the body and of the source inside the cavity.

It should be noted, however, with reference to an actual situation where a human is exposed to an EM field within, e.g., an industrial shed, that the position of the man is a tipically variable quantity, and the power absorbed depends on his position. It is therefore useful to define a parameter, independent of the man's position, which characterizes the hazard in terms of the maximum power the man can absorb by varying his position within the cavity.

This leads to the definition of a parameter characterizing the hazard of the surroundings (cavity + source) as the maximum value of r attained by varying the position of the body within the cavity:

$$r_1 = \max_{d} \{r\}$$

For given electrical characteristics of the source (current distribution and frequency), this parameter is a function of the source position inside the cavity. When installing EM radiating equipment in a shielded enclosure, it is possible, once the coefficient r_1 has been evaluated, to determine the better location for the equipment in order to minimise the hazard for the workers.

Finally, since the hazard also depends on the electrical and geometrical properties of the enclosure where the source-man interaction occurs, it seems convenient to characterize the hazard due to the enclosure, with reference to a given source, through the maximum value attained by r_1 by varying the location of the source:

$$r_2 = \max_{z'} \{r_1\}$$

This parameter, which is merely a function of the frequency, is simply the ratio between the maximum value of the average SAR in the actual structure and the average SAR in the reference conditions.

This parameter may be regarded as the hazard coefficient of the shielded enclosure.

3. NUMERICAL RESULTS AND DISCUSSION

The method described has been used to compute the EM field, the average SAR and its distribution inside the biological tissue in the structure in Fig.1. As the source of the EM field we have choosen an impressed current density in order to excite only the TM_{10} mode. This current density, omitting the time dependence exp(jwt), is expressed by

$$J_{is}(x,z) = I_0 \cos\frac{\pi x}{b}\,\delta(z - z') \qquad (5)$$

$t < z' < d$, where δ is the Dirac delta function and $I_0 = 1$ A/m in all the computations made. This current distribution makes it possible, on the one hand, to stress the major phenomena connected with the irradiation of a biological body inside a shielded enclosure. On the other hand, (5) does not appear to be too restrictive, since it may be considered as a single spatial harmonic (for m=1) of a current distribution having a generic x dependence.

According to the discussion in the previous section, only frequencies above the TM_{10} mode cut-off will be considered. In order to have an idea of the power absorbed by a human in actual conditions of interaction, we assume that a=6m, b=3m (dimensions of the cavity) and s=0.25 m (thickness of the biological tissue). It is obviously a rough approximation to consider a man occupying the whole height of the enclosure, but a model more closely relevant to man would not alter the main features of the phenomena.

Fig. 2 shows the behaviour of the ratio r between the average SAR's in the cavity and in the reference structure as a function of the position of the biological body inside the cavity; the curves are plotted for a source in a given position (z'=1.5 m) operating at the frequencies of 60,90, 120 MHz. Note that, given the amplitude of the current density, the average SAR in the reference structure, P_{ar}, is merely a function of the frequency; the values of P_{ar} at f=60, 90, 120 MHz are quoted in Fig.2.

The main feature of the curves in Fig.2 is the presence of typical picks of absorbed power. In fact, for each man position, the structure possesses an infinite set of discrete complex resonant frequencies; when, as d varies, the real part of one of these resonant frequencies approaches the operating frequency, a pick of absorption occurs. The maximum amplitude of these picks, corresponding to the previously defined parameter r_1,

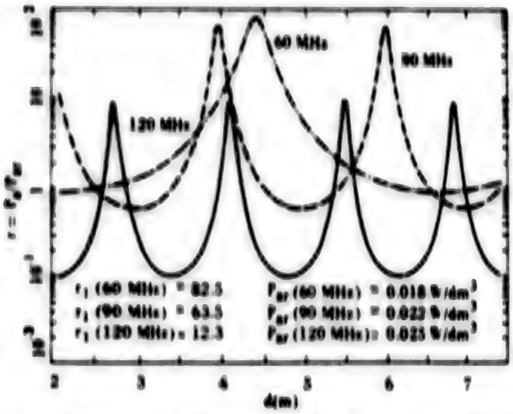


Fig 2 - Resonant cavity without absorber, z'=1.6m

is quoted in Fig.2 for the three frequencies examined. Fig.2 also illustrates the extreme variability of the absorbed power, both at a given frequency, as the position of man varies (~20 dB), and at a given position, as the frequency varies (~30 dB).

When the SAR in the reference structure is known, Fig.2 allows the evaluation of the SAR when the model moves within the shielded enclosure, as well as the recognition of the positions of greatest of lowest hazard.

The same diagrams of Fig.2, except for a different source position (z'=2m), are shown in Fig.3

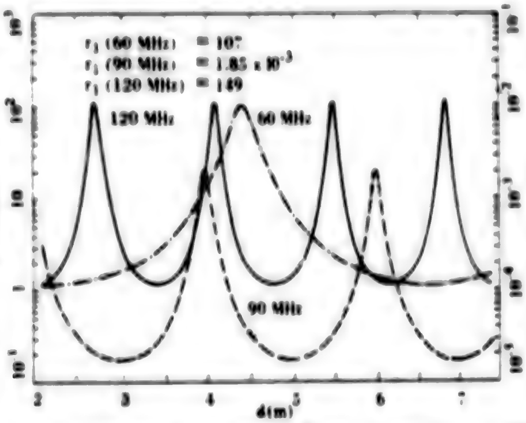


Fig. 3 - Resonant cavity without absorber, z'=2m.
The values of P_{ar} are the same of Fig.2.

Analogous considerations can be made for these curves; however, the variations of the absorbed power with the frequency are much greater (~70 dB) than in the previous case. It is worth noting that the normalized SAR levels at f=90 MHz for z'=2m are about 50 dB lower than in the other cases.

In the limits of the model adopted, this would be a very safe condition of interaction between source and man. As can be seen, this is due to the fact that, at f=90 MHz and z'=2m, the source is located at a minimum of the electric field E_z, so that the power radiated, as well as the power absorbed by the biological body, is very low.

The comparison between Figs.2 and 3 shows that, for a given frequency, the picks of absorption occur at the same man positions. The source position, in fact, does not affect the resonant frequencies of the structure, but only the radiated power; this quantity reaches its maximum when the source is located at a maximum of E_z along the z direction.

Fig. 4 shows the behaviour of the hazard coefficient, r_2, of the cavity examined, supposed to have perfectly conducting walls, as a function of the frequency. It is worth stressing the existence of a maximum of r_2 (~160) at about 80 MHz, which

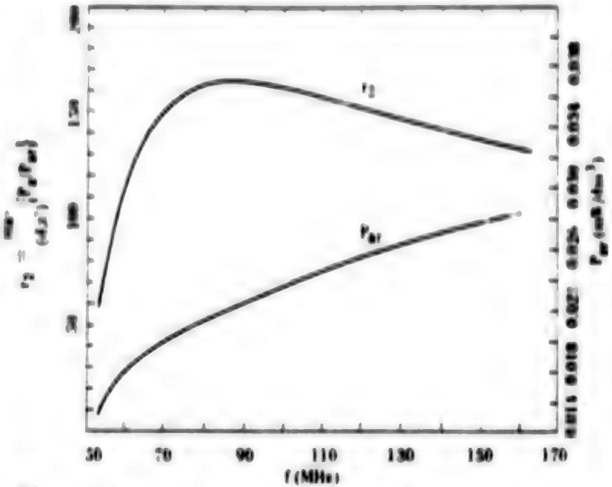
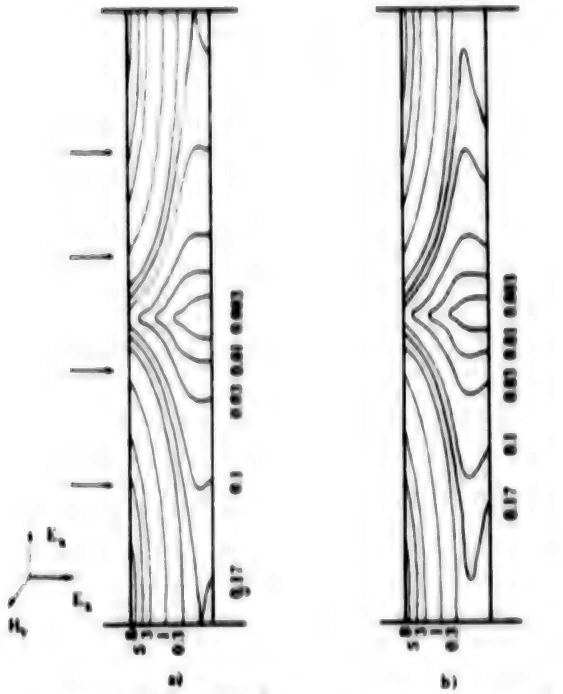


Fig. 4 - Hazard coefficient of the cavity (r_2) as a function of the frequency.

would be therefore the most dangerous frequency for the structure examined.

Since biological effects depend not only on the average SAR, but also on the SAR distribution inside the tissue [9], we have plotted (Figs.5 and 6) the iso-SAR lines inside the model placed in the structure of Fig.1a. These distributions are compared with the analogous ones obtained when the model is placed in the reference structure. Although only two particular cases (corresponding to the maxima of r at f=60 MHz, 120 MHz in Fig. 2) have been presented, no energy focusing effects nor hot spots seem to occur because of the presence of reflecting walls. This is due to the human model assumed; in our opinion, however, focusing effects would probably come out even in a plane human model, provided it does not occupy the whole height of the enclosure.

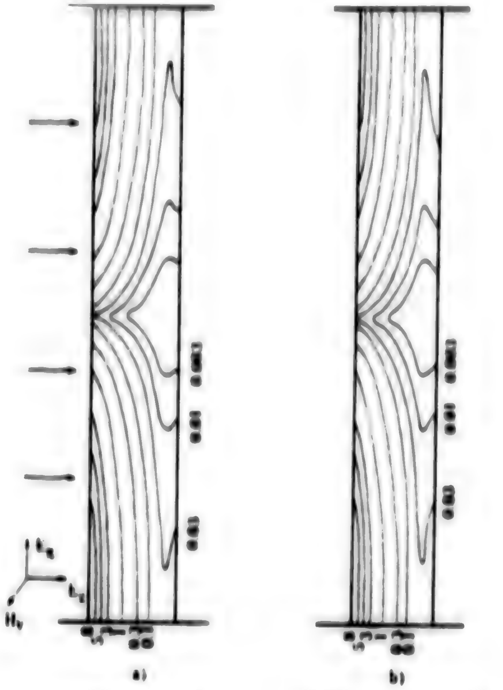

a)

average SAR = 0.018 W/dm^3

b)

average SAR = 1.75 W/dm^3

Fig. 6 - Comparison of iso-SAR lines within the model irradiated at f=60 MHz:
a) in the reference structure
b) in the shielded enclosure (source position z'=1.6m, model position d=4.4m).
The iso-SAR lines are normalized to the average SAR values.


a)

average SAR = 0.025 W/dm^3

b)

average SAR = 0.312 W/dm^3

Fig. 8 - The same as Fig.6 except for f=120 MHz, d=4.1m.

So far, we have supposed that the cavity have perfectly conducting walls, and that all the power radiated by the source be absorbed by the biological tissue. A model of an actual enclosure which is closer to reality is obtained by considering the presence of an absorbing layer, as indicated in Fig. 4a. In this structure, while the maximum possible absorption (i.e. the hazard coefficient r_2) will be likely less than in the totally reflecting cavity, the parameter r_1, i.e. the maximum absorption for a given source position, may be greater than before. The absorbing layer, in fact, has the effect of modifying the eigensolutions of the structure, and thus the distribution of the EM field.

The values of the average SAR, normalised with respect to the values in the reference conditions, have been then calculated for the structure with an absorbing layer 50 cm thick, having a complex permittivity $\varepsilon_r = 3 - j\,0.1$. The results obtained in conditions similar to those of Fig. 2 are shown in Fig. 7. Lower variations of the parameter r with the man position (∿17 dB instead of 20 dB) and with the frequency (∿ 20 dB instead of 30 dB) are obtained when the absorber is used. Though not conclusive, these results are indicative of the effects of partially reflecting walls on the interaction and suggest that the most dangerous condition of interaction is that which occurs in a totally reflecting cavity.

4. CONCLUSIONS

The interaction between a r.f.source and a biological body within a shielded enclosure has been examined. Even though the model adopted was rather rough, it has highlighted some basic aspects an led to some interesting conclusions. First, the existence of reciprocal man-source-enclosure interactions demonstrates the inadequacy of safety standards based on the exposure concept, i.e. on the hypothesis of biological body exposed to plane wave EM radiation. The approach based on the evaluation of the power density absorbed by the body is, on the contrary, much more meaningful. Second, our specific examples stress the dependence of power absorption on the position of man and of the

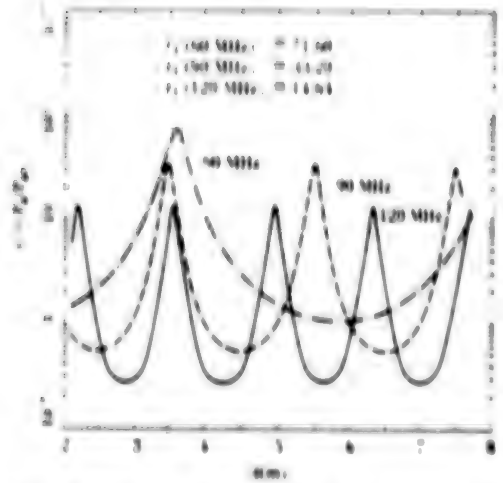


Fig. [illegible] - Resonant cavity with an absorbing layer [illegible]; a' = 2m. The values of F_e are the same of Fig. [illegible]

source within the enclosure; then the suitability of evaluating the absorbed power in terms of the absorption occurring in a reference structure was illustrated. Finally, some parameters were introduced which, according to a rather general hypotheses, make it possible to evaluate the hazard increase due to a shielded enclosure with respect to the reference condition of interaction. In particular, it is so possible to act upon the electrical characteristics of the source so that a given SAR will never be exceeded under any condition.

ACKNOWLEDGEMENT

The authors are grateful to Mr.B.De Santis for the drawings.

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Potentially-Polluting RF Sources

Milan ALTA FREQUENZA in English Mar-Apr 80 pp 76-84

[Article by Marco G. Bini, Amleto Ignesti, Luigi Millanta, Nicola Rubino, Riccardo Vanni, Istituto di Ricerca Sulle Onde Elettromagnetiche del C.N.R., Firenze: "A Comparative Analysis of the Various Potentially Polluting RF Sources"]

[Text] *Abstract.* The emission levels of the more common or typical R.F. field sources for which hazard problems have arisen are analysed and compared with the safety standards existing in the world. Problems arising in the evaluation of complex spatial and spectral field configurations are discussed and the more potentially hazardous situations are indicated. It is observed that hazard problems can only be expected in restricted areas (hot spots) close to powerful sources (essentially, heating apparatus). The measurement problem is essentially that of measuring reactive fields.

1. INTRODUCTION

In recent times attention has grown on the problem of the hazards connected to exposure to R.F. electromagnetic fields. As a matter of fact, the real stir began (around the late sixties) when news first spread in the western Countries about Soviet Union safety standards which were orders of magnitude lower than the commonly accepted American and European criteria. Now, after more than ten years of hot debates, the situation is far from being clarified. There is no general acceptance of a common exposure standard and, worse than that, there is no general agreement as to what the harmful effects of R.F. fields are. With the exception of a few well-known effects of thermal origin, we do not know whether the so-called non-thermal effects are to be connected to the electric or the magnetic fields, the power density, energy density, specific absorption rate, photon energy, body currents or potentials. This is the real problem underlying the serious but not that small problem of predicting or determining by measurement the R.F. exposure levels produced by the various typical sources of R.F. fields.

It is true that the increasing applications – industrial, military, medical, domestic – of R.F. energy have multiplied the sources and the occurrence of exposure. One often speaks in terms of a real pollution. The public opinion has often been upset by alarm injected or fanned by newspaper information insufficiently well documented. According to our experience, the alarm has been inversely proportional to the actual danger set up by the culprit source. A big warning or air-navigation radar causes much more alarm than a therapeutic appliance, or a modest radio beacon much more excitement than the old familiar radio broadcast tower or than a commonplace R.F. heat sealer. We shall see that it should not be that way.

The very concept of pollution should certainly be revised – or rather eliminated – substituting a more proper description of the facts in terms, perhaps, of hot spots. At most, the so-called environmental pollution should predominantly be attributed to the circular broadcasting because of its natural tendency to producing e.m. signals in urban areas. Actually, an experimental investigation [1] conducted in four U.S. urban areas in the frequency range 50 MHz – 900 MHz showed that only in a few spots (4 out of 70) was a power-density level of 1 to 2.5 µW/cm² reached 1), which is below the safest standards in the world (Soviet Union: 1 µW/cm² safe for unlimited exposure).

There certainly exist regions close to the sources where the e.m. fields reach levels that is necessary to control, to reduce, or to avoid exposing to. This leads to the need of dealing with the so-called near fields with their complex spatial and spectral configurations. The illumination conditions corresponding to a uniform plane wave are clearly most simple from the point of view of the theoretical analysis and the experimental determination. The plane-wave cases are however most frequently the ones where dangerous levels are not found. The more complex circumstances of the near field call for theoretical treatments and techniques of measurement and data analysis comparable to the complexity of the situation being described.

In the following we will analyse the emission levels of the more common or typical sources for which hazard problems have arisen in the past.

1. RADAR AND RADIO AIDS TO NAVIGATION

When Radar Frightens was the banner headline of a daily paper with regards to the installation of an Air Traffic Control Radar near Livorno, Italy. More dramatic expressions were used in connection with riots against a radio beacon to be installed on the coast near La Spezia.

We examined the hazards which could derive from these apparatus. In both cases the equipments were designed to irradiate regions of space inaccessible to people. The radiation levels have been evaluated on the basis of the design specifications, being the plants yet to be built. Auxiliary measurements were made on already operating systems of the same type.

The analysis of the power density versus distance from the source, in the direction of maximum irradiation, gives the maximum possible level in the far field region and allows a fairly approximated evaluation in the proximity and intermediate zones. The calculation of constant power density curves for values corresponding to the adopted safety standards permits to locate safe and hazardous zones. In the lack of Italian standards, reference has been made to the most restrictive standards existing in the world.

The above mentioned ATCR is similar to those already operating at the Rome and Milan airports: 1.8 MW peak power; 2.8 µs pulse duration; 450 Hz repetition rate; center frequency 1302.5 MHz. Possible operation in diversity with two transmitters gives a total average power of 4500 W. The antenna is about 10 x 3 m² large, with a maximum gain of 36.5 dB, 2° beam tilt above the horizon; horizontal beamwidth 1.2°, vertical beamwidth 4°, maximum secondary lobe level - 30 dB. The antenna rotates at 5 revolutions per minute.

The case of a rotating antenna leads to the problem of non-stationary fields. Two approaches have been used in dealing with this case. One [2] considers the irradiation averaged over one antenna revolution and maintains the low safety levels associated with continuous exposure; the other [3] considers the average power density with the antenna stationary but allows for higher permissible levels. The former criterion was adopted in our calculations.

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1) It should be noted that this figure corresponds to the sum of the powers across the whole band, which is not very consistent with a philosophy of the non-thermal effects.

The power density as a function of distance in the direction of maximum irradiation is shown in Fig.1. The straight line on the right represents the far-field range dependence. For the purposes of the present treatment the Rayleigh distance $r = D^2/2\lambda$ (D, width of the antenna; λ, wave-

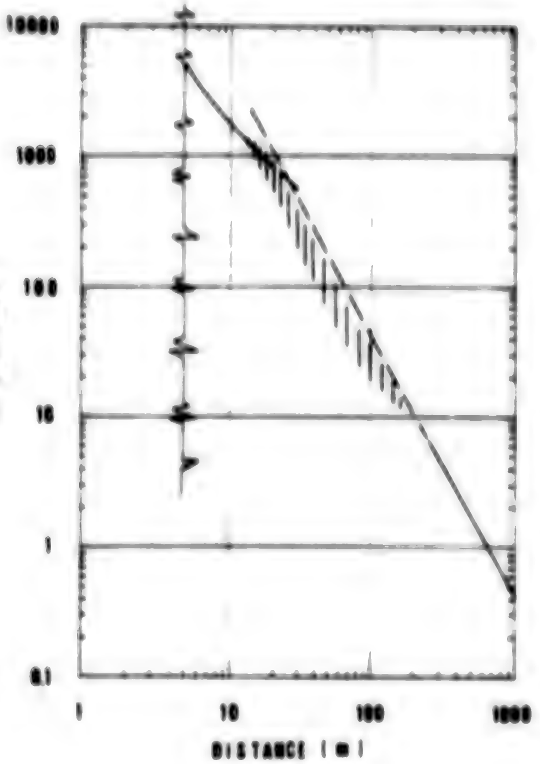

Fig. 1 - Power density versus distance in the direction of maximum irradiation for an ATCR apparatus.

length) can be considered an acceptable approximation for the far-field boundary. It can be seen that the level of 5 µW/cm², considered safe for continuous exposure by the Soviet Standards, is achieved at a distance of about 300 m from the antenna.

For short distances from the antenna (of the order of a few antenna apertures) the field was evaluated considering uniform illumination of the antenna aperture and a parallel beam radiating from it with negligible diffraction. The power density S at a distance r, averaged over one antenna revolution, is thus in this region:

$$S = \frac{P_{mi}}{\pi A} \sin^{-1}(D/2r$$

where A is the area of the antenna aperture, D is the maximum horizontal dimension and P_{mi} is the average radiated power. The curve is interrupted (left side of Fig.1) at a minimum distance of D/2 which is the radius swept by the antenna while rotating. The power density at this point is 5.3 mW/cm², and this is the maximum value of S to be expected in the space surrounding the antenna. If the antenna stopped its rotation this maximum power density would be doubled.

In the intermediate zone the power density can vary over a range approximately represented by the shaded area of Fig.1.

Human exposure in the direction of maximum irradiation is in our case a very unlikely occurrence and the calculated levels do not correspond to a real hazard, being the region involved inaccessible. A better representation in this respect can be obtained by tracing constant power density curves together with the position of the nearby accessible places. This is shown in Fig.2, where the radiation intensity outside the main beam has been assumed to be equal to that of the maximum secondary lobe. It can be seen that no accessible place is within the curve corresponding to a power density of 1 µW/cm².

It can be concluded that the apparatus is not hazardous for the civil population, even with respect to non-thermal reversible effects. Furthermore, everywhere in the space surrounding the antenna there are no risks of thermal effects.

Similar considerations have been developed about a typical TACAN radio beacon. TACAN systems operate in the frequency range 960 ÷ 1215 MHz. The r.f. power is pulse modulated by a gaussian-shaped pulse 3.5 µs long with a repetition rate of 7200 pulses per second. Peak power at the ground transmitter is 5 kW; power losses between the transmitter and the antenna can be assumed to be of the order of 6 dB. The antenna has an almost circular radiation pattern in the horizontal plane; in the vertical plane the direction of maximum irradiation is a few degrees (5°, in our case) above the horizon, with a gain of 9 dB. The antenna is about 1.5 m long and is typically located at 5 m (movable installation) or 15 m (fixed installation) above ground.

In the direction of maximum irradiation the safe value of 1 µW/cm² is found at a distance of about 15 m away from the center of the antenna.

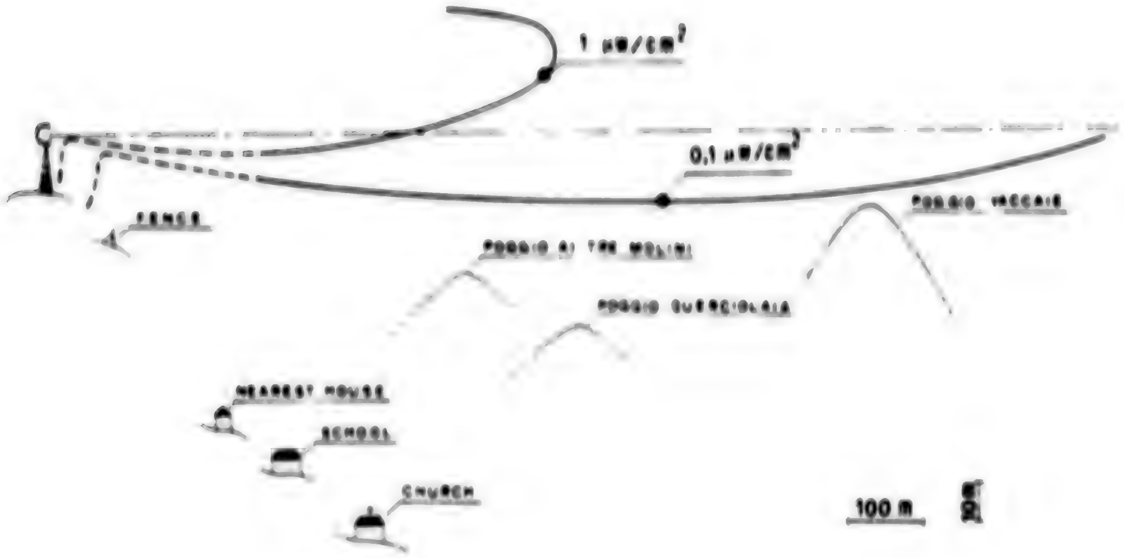

Fig. 2 - A representation of power density around the ATCR apparatus. Equal density curves and schematic representation of the relevant surrounding places (Livorno, Italy).

An evaluation of the power density in the near zone, considering the antenna as a source of uniform cylindrical waves, gives a value of 0.5 mW/cm² on the protective radome.

The power density at the ground level has been calculated on the basis of a typical vertical radiation pattern for two different antenna heights and the results are presented in fig.3. The power density remains below 5 μW/cm² everywhere.

In operating systems the situation is complicated by the presence of fences and other metallic structures. This was the situation of the TACAN equipment operating in Pisa, on which we performed field measurements. The center of the antenna is at 18.5 m above the ground level. A metallic mesh fence, 2.5 ÷ 3 meters high, surrounds the apparatus at a distance of about 10 m from the antenna at the closest point. The power density, as measured at 1.5 m above the ground level, (as shown in fig. 4) the observed level remains at about 1/100 of the safest permissible level.

The measurement techniques required for the kind of apparatus examined so far are merely those involved with radiated power.

The most relevant measurement problem is met with high-power radars with scanning or rotating beams. One has in fact to measure average powers (averaged with respect to the duty cycle of the pulse modulation) which are strongly varying in time. Let us consider the case of the ATCR previously discussed. The antenna revolution time is 12 s, while the main-beam illumination time at a fixed place is about 0.1 s. These figures must be compared with the time constants of the commercial

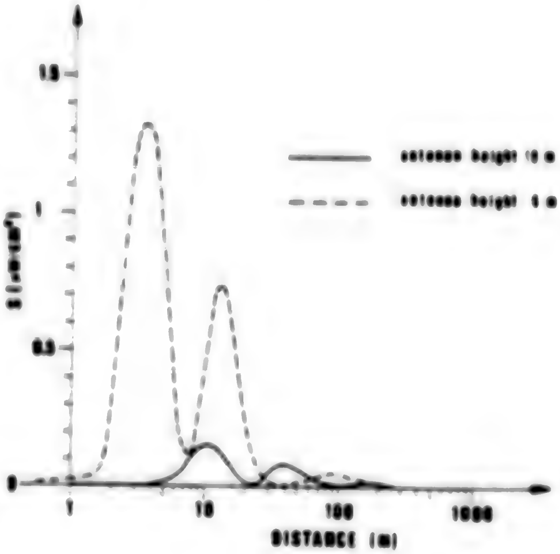

Fig. 3 - TACAN radio beacon; power density versus distance at the ground level for two different heights of the antenna.

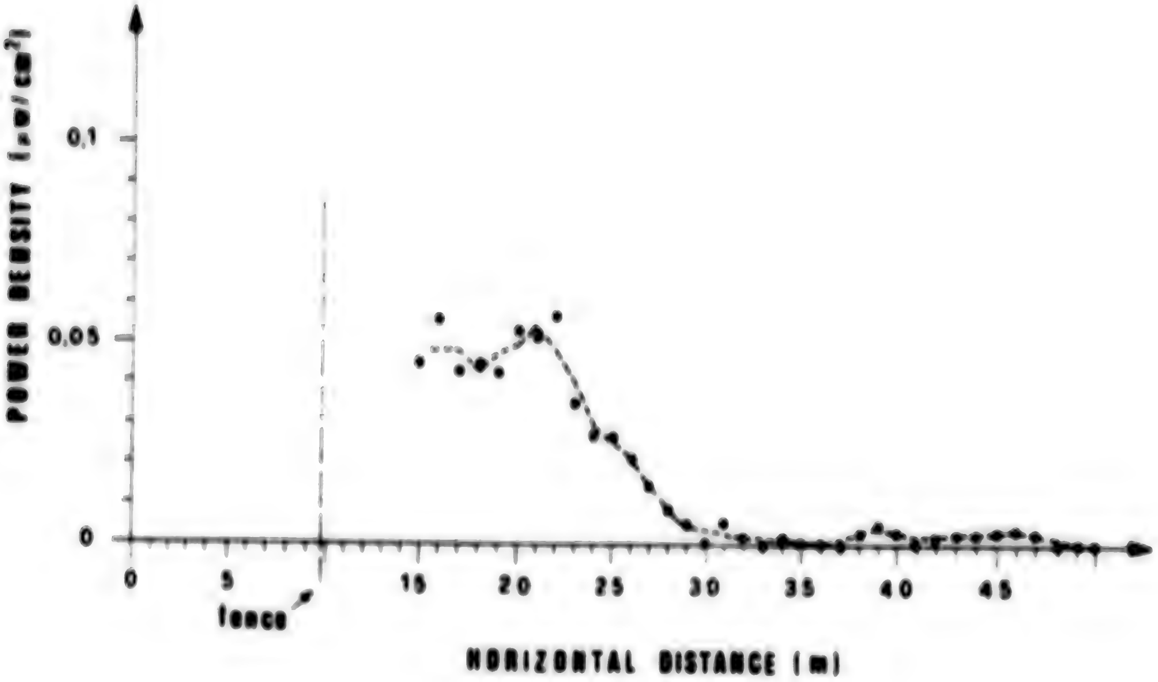

Fig. 4 - Power density versus distance measured at the height of 1,5 m above the ground level. (TACAN radio beacon at Pisa airport).

radiation monitors, typically 0.5 ÷ 1 s. Measurements performed on the field under normal operating conditions of the apparatus then require a suitable measuring technique and data processing.

3. BROADCAST RADIATION

We have anticipated in the Introduction that experimental evidence denies the possibility of epidemic exposure from broadcast stations: AM, FM and TV. There remains to check the possible existence of limited areas of substantial irradiation close to the sources. Such situation can exist in proximity to very powerful, ground-level transmitters, which is the case for some regional AM transmitters. There is a second case, which can be more interesting. In several cases, urban areas are served locally by low-power, in-town repeaters. These are placed most conveniently on top of some public building, such as a school or a public office. This creates the possibility of stray fields in a densely populated, restricted volume, directly below the R.F. source.

A typical high-power, medium-wavelength transmitter can have a power of 100 kW, plus up to 50 kW of modulation power. This is practically the case where the maximum field intensity in a space open to public can occur. Although the broadcast station's property is usually fenced to keep unauthorized individuals out, the fence can often be very close to the tower base and people can get as close as a few tens of meters from the antenna, and even less. Being the wavelengths involved so long, we are again in a near-field situation; a field strength considerably greater than the theoretical ground-wave field strength is to be expected. At the Florence-1 broadcast transmitter of the Italian national network we can observe field intensity values of several tens of V/m in the closest free-access surroundings: about 100 V/m rms at the nearest point of the fence (distance of about 25 m from the tower base) and about 50 V/m in the public road that coasts the fence. At the nearest building(about 50 m) one has 15 to 20 V/m in the road (the building is interposed between tower and road). No measurements were performed inside the buildings. The radio station has been there for more than half a century and for about 35 years in the present configuration.

Local AM transmitters find widespread use in the cities, where they accomplish the task of assuring coverage on blind spots or disturbed areas.

powers range from 100 to 1000 W at the amplifier output and much less than that can be expected to be radiated into space. In a typical arrangement, the transmitting module is located in an attic. The radiating system is fed via a coaxial cable. It consists of a dipole over a ground plane or counterpoise laid directly on the roof. More than one transmitter can serve the same radiator. The people in the building live directly below the radiator. This is a case where the radiated fields do not enter - practically - into play; the situation is essentially dominated by the ground plane and earthing system. Displacement or conducted currents can set up fields in a complicated pattern inside the building.

In a specific case we examined, there were two transmitters in a school (1062 and 1602 kHz, 1000 W nominal each) operating in a configuration such as the one just described. Substantial values of electric field strength were found in the top storey of the building, with a background level of 5 Vrms/m practically everywhere and local reinforcements in some rooms where values of 10 to 15 V/m could be observed at children's height and 20 V/m or more at man's head height. The contributions of the two transmitters to the total field were comparable in magnitude. No significant magnetic field was observed. Strong reinforcements in close proximity to extended metallic structures such as the main network or water plumbing suggested the presence of significant stray currents.

The above situation is one which is absolutely safe in the light of criteria based on thermal effects, which would allow a field of 375 V/m rms in this frequency range [4]. We are instead at about the limit of the more restrictive non-thermal standards. In this case, we suggested that a better earthing system and a better control of the stray currents should be established, mainly to obviate the unpleasant situation of a possible erratic and uncontrolled field distribution.

You may have noticed that we have stated the r.m.s. value of the total field. But now the real problem comes. In a case, like the one we are considering, where we have more than one source, we do not know how to compare the measured results with the safety standards. We do not know how the e.m. fields add *biologically*. Apparently this very basic problem has not come across the minds of the many experts who have issued or commented the non-thermally-based standards. In a multiple-field exposure (note that this includes also the single source with harmonics - a very important case) we are first faced with the problem of separating the single contributions to the overall field. If we are adopting a thermal standard, the thermal concept itself suggests that the r.m.s. value be compared with the safety level. In general, however, the single components will be weighted differently according to the frequency dependence of the safety level, and this unfortunately hinders the straightforward use of the wideband root-sum-of-the-squares, direct-reading instruments (e.g. Aeritalia, Narda). When it comes to non-thermal standards, then, we do not even know how to superimpose the effects: shall we take the absolute maximum instantaneous value? the average over a specified period of time? the amplitude of the largest component? the r.m.s.? and so on. In our case we merely chose the r.m.s. as the natural way to superimpose uncorrelated variables.

4. RF INDUSTRIAL HEATING MACHINES

Short-wave dielectric or magnetic induction machines find widespread use in industrial technological processes. The frequencies involved are in the range of the MHz, often one to ten MHz, with oscillator powers ranging from the kW to a few tens of kW, up to well beyond 100 kW for extremely powerful units. Their frequencies do not appear to comply with any regulations such as the US FCC allocated bands. The leaking fields do not appear to be primarily related to the oscillator power per se, but rather to the applicator geometry and to the grounding and earthing scheme.

Dielectric-loss heaters find widespread use in the furniture industry for drying or bending purposes and in the plastic industry for sealing purposes. The applicator consists of a pair of condenser plates, whose shape and distance and whose position with respect to the energy source can be widely variable. Fig.5 shows the electric field vs. distance behavior for a unit whose electrode geometry, position and grounding scheme appeared particularly favorable. The electrodes are a pair of plane, wide (1.3 m x 2.5 m), and closely spaced (2.5 cm) metallic plates, very close to the R.F. oscillator cabinet and close to the ground level (80 cm). A short ground path connects the lower plate to the common ground and earth. The nominal oscillator power was about 25 kW and the frequency was 4.5 MHz. Power and frequency stability were good, with incidental FM of less than 1 kHz. The electric field shown in fig.5 (peak value) was measured along a central line parallel to the long side of the applicator, at the gap center. The distance d is measured from the plate edges, outwards. The E field essentially represents the fringing field leaking out of the condenser plates. It is substantially vertical i.e.

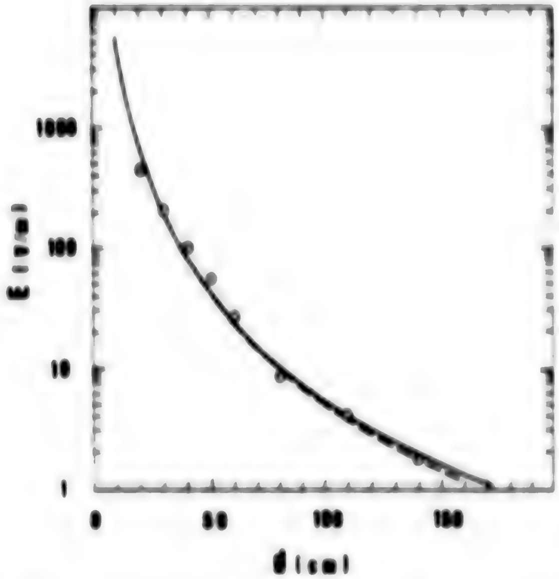

Fig. 5 - Electric field leaking out of a dielectric-heater versus the distance from the applicator edge. Solid line: best fitting power regression (exponent -2.95). Dashed line: inverse cube regression (exponent -3).

it is directed across the gap, as it should be. The line connecting the experimental points (solid line) represent a least-squares regression of the type $E = A\,d^k$, where A and k are constants to be determined. The exponent k turns out to be -2.95, and the fitting is very good (correlation coefficient 0.99). The exponent is very close to -3 which is the value corresponding to the field of a static electric dipole. The dashed line is a regression of the type $E = A'\,d^{-3}$. This behavior strongly suggests that we are in the presence of a quasi-static reactive field, closely bound to the applicator structure. This certainly represents a very desirable situation. Additional leakage fields appeared to be essentially of the conducted type. They mostly concentrated closely along the edges of the metallic loading-plane framework, ranging from 7 to 20 V/m (peak). Further care in grounding and earthing the structure should possibly reduce these values substantially, without resorting to probably unpractical R.F. choking and bypassing techniques.

Another example of R.F. dielectric heating machine shows a somewhat different situation. The basic data are comparable to those of the previous example: frequency 7 MHz, nominal oscillator power 20 kW. The type of service is about the same (bending and glue-curing on wood). In this case, however, widespread leakage fields were found throughout the room, essentially supported by extended metallic structures, such as the electric network, compressed-air tubing, ventilation ducts, metallic gates. The frequency and power stability were also found to be poor, with marked variations along the heating cycle, frequent need for retuning and a short-term incidental FM of 10 to 15 kHz. The lack of stability reflects upon the leaking fields, with essentially unpredictable time and space variations. The applicator electrodes were a pair of curved plates about 1 m x 0.7 m, with a separation of 1.5 cm and they were placed high above ground (1.8 m) and distant from the oscillator cabinet and the supporting structure (pressure plates and framework). The hot and ground leads (metal straps) were fairly long, around one meter or more, and this certainly favored potential differences among the various parts of the ideally common ground and between this and the earth, and coupling to the external structures. Power and frequency variations were consequent to loading variations during the heating cycle, as reflected onto the oscillator.

The electric field was measured along a central line away from the applicator gap edge. Fig. 6 represents the E field (rms value) vs. distance for this case, in a presentation similar to the previous fig.5. Several readings were taken at different distances and times during the heating cycle and over several cycles to take the erratic variations into account. A least-squares regression line of the type $E = A\,d^k$ was again fitted to the experimental points. This time the exponent did not identify a specific negative (integer, or possibly fractional) power of the distance: $k = -1.9$, indicating a more complex structure of the field sources than a simple electric dipole. In a case such as the one in this example it would certainly be impractical to depict all details of time and space variations of the field. This would not be good engineering practice, and, after all, an improperly performing machine does not deserve such expense and effort. We have chosen instead to deal with the problem on a statistical basis. The criterion we have adopted is a follows. Once a sufficient number of experimental points has been taken and a suitable regression law determined, the standard deviation of the measured field values from the expected values is computed and the curves deviated from the best-fitting curves by ± 1 std.dev. are plotted (long-dashed lines in fig.6). The area inside the curves corresponds to field values deviated from the expected values

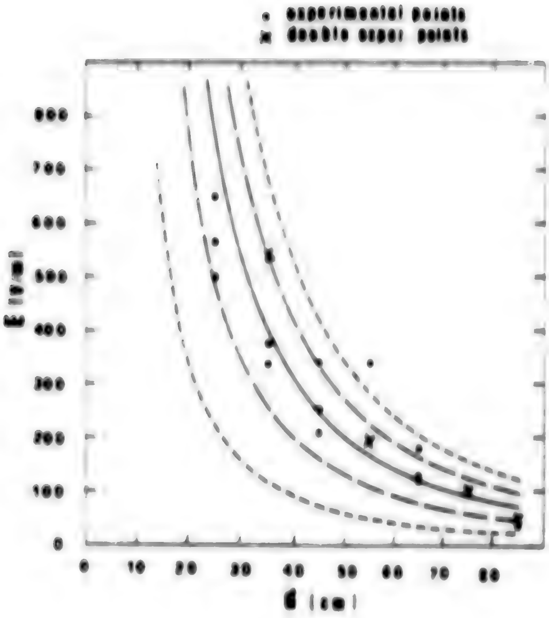

Fig. 6 - The same representation as in fig. 5 in a different apparatus showing a much wider scattering of the measured values. The best-fitting power regression is represented (solid line) along with the curves deviated by one (long-dashed lines) and two (short-dashed lines) standard deviations.

by less than 1 std.dev. The curves deviated by ± 2 std. dev.'s are also plotted in the figure (short-dashed lines). The safety standards are then compared with the values predicted by the best fitting curve plus one standard deviation. This is a more sensible procedure from the physical point of view than merely taking the average or the highest values observed at a given point at several times, or at several points at a given time. This procedure gives a more reliable and possibly a safer determination by taking advantage of the correlation among values at different points and different distances. If required, the safety standards can be compared with the curve augmented by two standard deviations. This would be, for instance, the case when one compares with an absolute maximum value (zero exposure time). The full-time, or working-day exposure limits would instead be compared to the + 1 std.dev. curve. It is evident that this procedure readily lends itself to the sistemization of the measurements in complex environments, and to the enforcement of standard measurement regulations. If the average is extended conveniently in time, this method also takes into account random or quasi-random variations produced by external agents, such as movement of persons or materials or equipment in the surroundings. Finally, this criterion penalizes from the regulations point of view the manufacturing of unstable machines, which is also a desirable feature.

Fig. 7 - Optical fiber drawing machine: general view.

The other class of heating machines is represented by the magnetic-induction type. This is widely used for the heating through eddy current losses in metallurgical technologies, or in any technologies which may require a highly clean process (e.g. zone refining). One such machine is being used for the fusion of quartz in the drawing process of optical fibers at I.R.O.E. A sixteen-turn solenoid, 18 cm in diameter and 16 cm long, heats the crucible to 2000°C. The oscillator power is 2.5 kW at a stable frequency.
The heating and drawing apparatus is enclosed in a plastic/metal box, see fig.7. There is a grounded shield for safety purposes, in the form of a

metal basin just underneath the coil, directly grounded to the oscillator cabinet.This is in turn efficiently earthed. When the shield is not in place, one finds levels of 100 V/m in the room and 1000 V/m near the applicator (50 cm), at locations where the operators have access during the process to control the fiber growth. These field values were considered unacceptable from the safety point of view. With the addition of the shield, the field in the most dangerous region is reduced from 1000 to 100 V/m. At man's head height within the box one finds about 10 V/m and about 1 V/m outside the cabinet. Conducted interference along the power cord gives 2 to 3 V/m maximum. This can be considered perfectly satisfactory.

The magnetic fields never reached values of concern. With the shield in place the values remain of the order of 0.1 A/m across the box. Only in the immediate vicinity of the applicator do the H values rise above 1 A/m. The nearest point accessible with the machine operating is near the shield (15 cm) where we have 1.4 A/m.

We can conclude that the order of magnitude of the stray fields to be expected in connection with RF heating is of hundreds of V/m in the vicinity of the applicator, with magnetic fields of the order of 1 A/m or less. The stray, or fringing, fields of the applicator itself can be expected to rapidly decay with distance with negative powers lower than -1, down to -3. When substantial values of field strength are found away from the source, these are to be attributed to conducted interference along metallic structures and not to radiation. Coupling from the generator to the surroundings is likely to be due to improper installation of the apparatus, mainly the position, grounding and earthing of the various parts. A good control of the shielding of the hot parts and filtering of the power lines may also be required. With a reasonably good care of the above requirements, values of field strength complying with the most restrictive standards should be attained, everywhere but in the immediate vicinity of the applicator (say, 1 meter).

5. BIOMEDICAL APPLICATIONS

Therapeutic applications of R.F. and microwave diathermy typically generate situations of a complex e.m. environment in a restricted space, with the possibility of several hot spots. These are attended both by patients and by medical personnel. Typically one has the simultaneous presence of several appliances in the same room, at both short-wave and microwave frequencies.

There appears to be a fair degree of standardization. In practice one finds the 27.12 MHz frequency for the short-wave diathermy and the 2450 MHz for the (less diffused) microwave diathermy; both frequencies complying with the ISM bands allocated by the USA FCC. Powers are typically 400W for short-wave and 120 to 200W for microwave apparatuses.

The short-wave appliances we examined were all manufactured by two big international firms, and they turned out to perform essentially the same, from the safety point of view, the principal characteristics of the stray fields being primarily due to the geometry of the applicators, which turned out to be more or less standard. The types of applicator are: a) single coil, for large flat areas; b) dual coil for the treatment of limbs or shoulder on both sides; c) flexible cable, about 1 m, to be coiled around limbs, or trunk or neck; d) plane circular capacitor, about 15 cm diameter, for the same applications as in b), possibly with wider separations.

The leakage fields have been measured with the apparatus in normal operating conditions and with the patient in position. Again, it has been found that the relevant quantity from the safety point of view is the E field, the H field never reaching values conflicting with the safety standards.

The capacitor is by far the type of applicator which gives rise to the largest amount of stray fields. We give as an example the values observed for the typical situation of a patient in the sitting position with one arm in the applicator, see table I.

Table I

Point of observation	E field (V rms/m)
eye	450
abdomen	1000
crotch	750
back	350

The E field is 400 V/m at 1 m distance and rises at 1000 V/m near the feeding conductors (30 cm). At the control board of the cabinet one finds 50 to 100 V/m.

The other types of applicator are much more favorable from the point of view of stray fields.

with a double-coil applicator placed on the shoulder, strong fields are only found in close proximity to the applicator (400 to 800 V/m at a few centimeter distance) and, as before, to the feeding cables (1000 V/m). Near eyes and crotch one has 50 V/m and about 10 V/m at the control board. The coiled-cable applicator is, as expected, qualitatively similar, with intense fields around the cable, rapidly decaying with distance (1000 V/m at 10 cm, about 10 V/m at 1.5 m).

The field structure set up by microwave appliances is obviously simple compared to the short-wave appliances. In a standard set we found a nominal radiated power of 200W at the standard frequency of 2450 MHz. The 3-dB beamwidth of the applicator turned out to be about ± 30° with a gain of about 15. A level control was capable of about 10 dB variation in the radiated power. This is essentially all there is as to the power density distribution in the room. Thus the thermal safety level of 10 mW/cm^2 is reached at 0.5 m with the control set to minimum power and at 1.5 m with maximum power. The heating power density level in excess of 100 mW/cm^2 is reached at a distance of less than 0.5 m. These radiation characteristics point out the possibility that a substantial portion of the power dissipation take place in parts of the body other than the one being treated.

We have thus seen that a diathermy laboratory is one of the very few examples of a potential exposure to multiple sources, and one of the very few places where hot spots can be found with field strength or power-density values exceeding the non-thermal standards. The thermal standards also must obviously be exceeded - for the patient - but this occurs under specific medical control, and is an entirely different matter than the problem of environmental health or occupational safety. Care should be taken, though, that unwanted radiation or fields escaping from the apparatuses fall onto body parts other than the one subject to treatment, and also that personnel and other patients in the laboratory area be unduly exposed.

6. MICROWAVE ANTI-INTRUDER ALARMS

Considerable concern has also been expressed about typically low-power devices such as the microwave anti-intruders. One might wonder why one should worry about the safety of the burglars. The reason is that the device can be kept in continuous operation, with the alarm circuit inactivated, to avoid thermal drift or switching problems, thus exposing the personnel in the area to be protected throughout the working day.

With the power, frequency and type of antenna involved, the theoretical and measurement problems can invariably be dealt with in the point-source approximation, down to the shortest distances of practical interest. The frequencies allocated are 10.525 GHz and in some cases 9.47 or 9.80 GHz. In any case, the wavelength is about 3 cm. Being a volumetric alarm, the beam is usually spread out, the antenna gain is low, and so are the antenna dimensions, which are seldom beyond a few centimeters across the mouth. Thus the point-source approximation can be considered perfectly satisfactory for our purposes down to a few tens of centimeters.

With a typical gunn-diode power of 10 mW and a gain of 15 dB, the Soviet occupational safety standard of 10 $\mu W/cm^2$ is reached at a distance of 50 cm. For reasons of good performance the device is tipycally placed at a height above ground from about 2.5 to 3.5 meters. It is therefore extremely unlikely that a situation takes place where a person's working position is such as to place, say, his head within a 0.5 m distance from the radiator.

7. CONCLUSIONS

We have seen that among the many sources of e.m. fields or radiation that have caused alarm in the public opinion and in the technical and scientific community, very few are of some practical concern for the human health. These are essentially limited to the field of heating: R.F. industrial heating and medical diathermy. There can be a few peculiar exceptions, e.g. power broadcast radiation in close quarters. In any case, alarm in terms of public environmental pollution is never justified: substantial radiation or stray fields are invariably found in some limited proximity to the sources (hot spots). This applies both to the radiated fields, with their one-over-distance decay law, and to the, usually stronger, but more rapidly decaying, near fields. Incidentally, it should be made clear to the public opinion that the so-called e.m. pollution is by no means accumulating with time in the ambient as would for instance be the case with chemical pollution. The e.m. pollution disappears immediately after the source is switched off.

There is one real big problem in the field of e.m. environmental health, and that is to know how the electric or magnetic fields or e.m. radiation interact with the living organism to cause harm. Once this knowledge will be made available, we will known what the dangerous quantities are, and guard against accordingly. Until then, we will not know how the measured quantities should be compared to the safety standards. A clear example of this inability is the important practical case of exposure to complex e.m. fields: simultaneous presence of E and H fields, several frequencies involved, either uncorrelated (multiple sources) or correlated (harmonics). In this case, the non-thermal standards do not offer guidance as to how the several stressing agents should be summed to give a measure of the overall hazard.

The problems of analysis and measurement on the potentially harmful sources are essentially those of analyzing complex time - and space - varying distributions of electric and magnetic fields. In cases where the r.m.s. value of the overall electric or magnetic field is an adequate measure of the hazard, the commercial square-law, root-sum-of-the-squares, isotropic monitors of E or H fields give directly the answer. When the single components are to be separated, more complex techniques are needed, up to the complete spectral analysis by means of E and H polarized probes, R.F. coupled to the receiver. In all cases where the sources are unstable or random, statistical techniques of measurement and data analysis can solve the problem. The standards to come could advantageously acquire this concept.

Finally, it is the feeling of the Authors that it is possible to comply even with the present most restrictive safety standards, in all practical cases of R.F. and microwave sources. The techniques required, i.e. grounding, earthing, filtering and shielding should not add significantly to cost and ease of use.

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Electromagnetic Compatability, Noise Pollution

Milan ALTA FREQUENZA in English Mar-Apr 80 pp 124-129

[Article by Claudio Egidi, of Istituto Elettrotecnico Nazionale Galileo Ferraris, Torino, Centro di Studio per la Televisione del CNR, Torino, and Istituto di Elettronica e Telecomunicazioni, Politecnico di Torino: "Electromagnetic Compatability (EMC) Today: A Review (1979-80)"]

[Text] The paper is mainly directed to researchers and technicians specialized in individual scientific and technical fields, such as antennas, electromagnetism and many others. It aims at stimulating their investigations towards the theoretical and practical problems of EMC.

The main International Bodies concerned, such as IEC, CISPR, URSI, and EBU are recalled and their activities mentioned and commented on. The most relevant topics considered in the EMC Symposia held during the last five years, are listed.

Work carried on in CISPR and its organization are explained in detail.

Finally, the titles and authors of the papers contained in this special issue are reported and subdivided, under some headings contained in the above mentioned EMC Symposia.

1. INTRODUCTION

Unintentional radio noise produced by

(*) This paper is restricted to non-military applications of electromagnetic compatibility (EMC) and is mainly devoted to the work carried on in the CISPR.

electric and electronic devices has been taken into consideration for a long time and called "man-made noise".

Before the second world war, increasing attention to this field coincided with a decreased investigation into atmospheric radio noise, that urged the first generation of radio researchers and technicians In fact, they were mainly faced with the very sensitive receivers developed for the long and medium wave reception of relatively weak and distant transmitters.

Intentional radio noise is a typical subject of the war time and we truly hope not to have to consider it again.

While the systematic study of man-made noise began around the period between the first and the second war, the outstanding spread of electric and electronic applications occurred during the last three decades and the consequent expansion of interference gave rise to a new investigation area, called with the new term of electromagnetic compatibility (EMC). This new interdisciplinary science and technique embodies all the aspects of the radioelectric coexistence: radio and television networks planning, with reference to frequency allocation, radiated power and radiation diagrams of the individual transmitters; any type of radio frequency generator not conceived for communications; any other unintentional radio frequency generator, such as car ignition systems and many other appliances, all responsible for interference to low level electronic devices, typically but not exclusively to radio and television receivers.

However, in recent times another relevant chapter was opened, considering the biological effects on living organisms and particularly on the human body. This is a continuously enlarging field: a review of the most typical subjects and results is contained in the companion review paper, by Paolo Bernardi and Guglielmo d'Ambrosio.

2. RECENT AND PRESENT INVESTIGATIONS

Starting from a rather restricted subject, that just before the second world war was mainly focused on broadcast radio receivers as objects of interference and commutator motors as generators of interference, attention was progressively extended to many other subjects. These were and are carefully and promptly recognized and investigated by national industries and laboratories and promoted and standardized by national and international Bodies.

IEC (1), through some Technical Committees, Subcommittees and Working Groups, but mainly through CISPR (2), takes the charge to follow and coordinate the international progress in this field and to operate in view of different degrees of noise suppression.

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(1) TC 12, through the WG 1 of SC 12A, will be considering for some time the methods of measurement of radiation and immunity of radio and television receivers. Also SC 12F includes a method of measurement for radiation of car ignition systems, as they affect mobile receivers.
Moreover, WG 4 of SC 12G has the task to establish methods of measurement and limits for cabled television systems.
Other similar subjects are being considered in TC 65 and 77: they concern problems such as susceptibility and emission of disturbances from industrial-process measurement and control instrumentation.

(2) CISPR (= Comité International Spécial des Perturbations Radioélectriques = International Special Committee on Radio Interference), founded in 1934 as an independent International Body, differs from IEC because it studies methods and recommends limits for the various types of radiated and conducted noise. However, in 1974 it has been more firmly included in IEC, from the organizational and procedural point of view.
CISPR is subdivided in six Subcommittees, namely: A) Radio Interference Measuring Equipment; B) Interference from Industrial, Scientific and Medical Apparatus; C) Interference from Overhead Power Lines, High Voltage Equipment and Electric Traction Systems; D) Interference Relating to Motor Vehicles and Internal-Combustion Engines; E) Interference Characteristics of Ra

Relevant CISPR documents are contained in the following bilingual publications (English and French in the same issue):

IEC-CISPR - Publication 7 - Second Edition - 1969 - Recommendations of the CISPR.

IEC-CISPR - Publication 7A - 1973 - First Supplement to CISPR Publication 7 (1969).

IEC-CISPR - Publication 7B - 1975 - Second Supplement to CISPR Publication 7 (1969).

IEC-CISPR - Publication 8 - Second Edition - 1969 - Reports and Study Questions of the CISPR (Approved or confirmed at the Plenary Session of the CISPR in Stresa in 1967).

IEC-CISPR - Amendment No 1 - May 1973 - to CISPR Publication 8 (Second Edition - 1969) Reports and Study Questions of the CISPR. Amendments approved at the CISPR Meeting held in Leningrad in October 1970.

IEC-CISPR - Publication 8A - 1973 - First Supplement to CISPR Publication 8 (1969). Reports and Study Questions of the CISPR.

IEC-CISPR - Publication 8B - 1975 - Second Supplement to CISPR Publication 8 (1969). Reports and Study Questions of the CISPR.

IEC-CISPR - Publication 9 - Fourth Edition - 1978 - Limits of radio interference and leakage currents according to CISPR and national regulations. Section One: CISPR limits of radio interference and report of national limits. Section Two: Maximum permissible values of leakage currents and limiting values of capacitance and energy for radio interference suppression capacitors.

IEC-CISPR - Publication 16 - First Edition - 1977 - CISPR Specification for Radio-Interference Measuring Apparatus and Measurement Methods.

Publ. 16 has been prepared by SC A.

Publications 11, 12, 13, 14, and 15 concern methods of measurement and limits belonging respectively to SC B, D, E, and F (14 and 15); in other words, these publications contain in a different order the

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(2) cont.

dio Receivers; F) Interference from Motors, Household Appliances, Lighting Apparatus, and the Like.
Specific terms are defined in the International Electrotechnical Vocabulary.

same Recommendations and Study Questions mentioned above.

At present, the regular updating of the above texts is no longer printed, but is presented through stencyl CISPR documents.

Also URSI (3), initially with relatively weak impetus (around 1960), but now with increasing interest, takes care of the scientific aspects of radio noise. They separate the e.m. radiation effects on living tissues and organisms from the same effects on electronic devices, including natural radio noise.

EBU (4), highly interested to these problems, has recently published the Technical Monograph N. 3115, 1974, entitled "Organization of measures to control electrical interference with broadcast reception", by E.L.E. Pawley. CCIR is also interested.

All these subjects and several others, combined with transmitters problems and collected under the general above mentioned heading of EMC, gave rise since many years to publication of a special review. This publication was initiated in 1959 and formerly called IRE Transactions on Radio Frequency Interference (Vol. I-V, 1959-63), while since 1964 it has been called IEEE Transactions on EMC, Vol. VI. These Transactions are now being published four times per year and represent a fundamental contribution in this field.

Some specific books have been published (5).

Moreover, annual Meetings are being held on EMC, beginning in 1959 in USA and in 1972 in Europe (Wrocław, Poland). At present, Western and Eastern Europe alternate their Meetings in a coordinated way, respectively in Montreux, Switzerland (however, in 1979, Rotterdam was chosen instead) during the odd years, and in Wrocław, Poland, during the even years. The next Meeting will be held in Zurich, Switzerland, on March 1981.

It is useful to remember the most important subjects considered during the last five years (1975-79) in the above Meetings.

The following list of subjects has been drawn up from the records of the Symposia held in Washington, D.C., in 1976, in Atlanta, GA, in 1975, in Montreux, Switzerland, in 1977 and 1979, in Wrocław, Poland, in 1978. Natural phenomena, such as lightning, are considered sometimes.

Avionics and space, avionic systems
Antennas and propagation - Antennas and field analysis techniques
Automatic measuring systems
Analysis and prediction - Interference analysis
Biological effects, biological aspects of EMC, biomedical
Car electric noise
CISPR type of measurement
Communications and cables - Effect of radio noise on telecommunication systems
Composite man-made radio-noise and its effect
Computer and data processing
Design for EMC
Effects of lightning
Electric fields
Electromagnetic pulses (EMP) - Nuclear electromagnetic pulses (NEMP)
ELF interference
EMC and the hospital

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(3) URSI (Union Radio-Scientifique Internationale = International Union of Radio Science) is an independent scientific Body, coordinated to some extent by ICSU (International Conference of Scientific Unions). It was founded in Brussels in 1919, and is organising regular meetings, called General Assemblies, every three years, now alternatively in Europe and outside Europe, while more restricted Symposia on specialized subjects are being held inbetween.
URSI is subdivided into nine Commissions, two of which are connected with the subjects of the present special issue of ALTA FREQUENZA, namely partially Commission A (Electromagnetic Metrology - Bioeffects of EM waves) and more specifically Commission E (Interference Environment). The last General Assembly was held in Helsinki, from the 1st to the 8th of August 1978: EMC contributions were particularly successful.

(4) EBU (= European Broadcasting Union) or UER (Union Européenne de Radiodiffusion) has its Technical Centre in Brussels, Belgium.
CCIR (Comité Consultatif International des Télécommunications).

EMC fields
EMC figure of merit
EMC in power systems - High voltage and power lines
EMC in radiocommunication
EMC problems in high voltage installations
EMC system specifications
EM environment
EM hazards effects
EMI and computers
Environmental interactions
Immunity - Immunity and susceptibility
Immunity and performance degradation
Interference sources and hazardous emissions (see below, under "sources")
Legal aspects and standards
Magnetic fields
Materials
Measurements and instrumentation
Measuring methods and production testing
Methodology of systems
Modeling and measuring noise and interference - System modeling
Penetration (field penetration of shielded barriers)
Propagation (see above under "Antennas and propagation")
Safety and EMC
Shielding - Shielding in cables, connectors and assemblies
Ships and transport
Sources of interference (see above under "interference sources")
Statistic of noise - Statistical considerations
Spectrum management - Spectrum protection
Suppressors - Suppression and control
Testing and measurement
Wire coupling

Applications of nonsinusoidal functions; frequency analysis, synchronization, filtering; Walsh functions.

The list shows clearly how broad the compatibility area now is: it is also consequently difficult to arrive at a logical subdivision. Presumably, this will be made with progress of time for the new applications: at present, CISPR can be considered as an example of fairly stabilized organization of subjects, hopefully to be followed by other Bodies.

Going into some detail on the quoted individual Symposia, particularly concerning the interest of different nations for EMC, the Rotterdam 1979 Symposium has been taken as an example. 110 papers were submitted and introduced by 165 authors, belonging to twenty nations and international organizations. In decreasing order, 30 papers were submitted by USA, 6 to 10 papers by each of the following Countries: France, Federal Republic of Germany, Italy, Switzerland, United Kingdom, USSR; 5 or less, by others.

In various Countries, National Committees are active, not only as the national affiliations of CISPR and IEC, but also as the expressions of independent or continentally coordinated Electrotechnical Associations. As an example, in Italy, AEI (Associazione Elettrotecnica ed Elettronica Italiana), coordinated both with EUREL in Europe and with IEEE in USA, has founded a Specialistic Group called "Compatibilità Elettromagnetica".

In an attempt to outline the major problems faced during the last five years by IEN and CISPR, the following can be said.

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5) As an example, four European and four American books are quoted:
A. Warner: Taschenbuch der Funk-Entstörung. VDE Verlag GmbH - Berlin - Charlottenburg, 1965.
E. Fromy: La mesure des parasites. Editions Chiron, Paris, 1976.
W. Rotkiewicz, (Ed.) Electromagnetic Compatibility in Radiocommunication Systems, Kompatybilność elektromagnetyczna w radiotechnice. Wydawnictwa Komunikacji i Łączności, Warszawa, 1978. (In Polish). Note: An English version of this book is planned for release by Elsevier Publishing Co. in 1980.
E. Nano: Compatibilità elettromagnetica (Radiodisturbi). Quaderni di Elettronica. Boringhieri - 1979. (In Italian).
R.E. Ficchi: Electrical Interference - London, Iliffe Books Ltd., 1964.
NASA SP-3067: Radio Frequency Interference Handbook. National Aeronautics and Space Administration - 1971.
E.N. Skomal: Man-Made Radio Noise - Van Nostrand Reinhold Company, New York, 1978.
J.R. Herman: Electromagnetic Ambients and Man-Made Noise, Vol.III, Multi-volume EMC Encyclopedia Series, Don White Consultants, Inc., Gainesville, VA, 22065, 1979.

Unintentional noise generators have been progressively classified and carefully investigated by CISPR, in order to update the knowledge of their characteristics and the most convenient means to suppress or, better, to abate the noise.

Concerning the classification, well represented by CISPR subdivision into Subcommittees, the same order can be followed.

I.S.M. (SC B) combines the characteristics of H.F. and microwave medium and high power generators, not intended for communication. Noise is of the narrow band type (a carrier wave sometimes incidentally modulated by the residual hum of the mains frequency). Industrial apparatuses are generally either dielectric ovens for wood and plastics drying and soldering or melting; for food defrosting, cooking and drying; or inductive ovens, for metal melting, surface hardening and soldering. They are characterized by appreciable and sometimes large dimensions, so that shielding is difficult; moreover, for economic reasons, their frequency is often appreciably drifting during the entire cycle of operation. In order to reduce and suppress to the highest possible extent their undesired radiation, it is recommended to stabilize the driver frequency and to introduce shieldings and choke coils, against radiation and, respectively, conduction through the power line.

Scientific apparatus include a variety of devices and instruments difficult to frame.

Some medical apparatuses are also similar to the idustrial ones (such as equipments for R.F. therapeutic purposes), but there is to-day a considerable variety of types.

For the ISM apparatus, CISPR recommends in general to fulfill specified field strength limits at specified distances and with standard dispositions. Microwave power measurements in a reverberating radio enclosure are also carried on with success. A paper on such subject is contained in this issue.

It seems rather difficult to obtain in the near future a significant abatement of noise in all these appliances, probably except for the case of microwave food cooking ovens, thanks to the small dimensions and the possibility to provide an effective shielding, combined with safety requirements for the operator. The same safety requirements apply to any R.F. power generator.

Power lines (CISPR SC C) can be considered at the same time as generators and conveyors of radiation. They give rise to interference, due both to corona effect and to dirty insulators, producing short sparks across dry bands. Corona generates long and medium wave interference, while dirty insulators mainly interfere television reception. The suppression of the former type of interference is rather expensive; however, mutual dependence between noise and corona is favourable, because power engineers in their efforts to reduce the losses simultaneously reduce - to some extent - also the noise. In high voltage power lines, this result is obtained increasing the equivalent external diameter of the conductors, according to the technique of conductors bundles with different subconductors.

In adverse weather conditions, however, high R.F. field levels are produced. CISPR Recommendation, in this case, can be fulfilled only on a statistical base; the relevant manual is in preparation.

Ignition noise (CISPR SC D) has been studied and investigated extensively in the past, as it is characterized by high voltage pulses, synchronous with the motor rotation. Suppressors of different kinds, but particularly of the reactive type on the spark-plug cable connections and of a resistive type on the distributor, represent a reasonable compromise between suppression efficiency and economy, for the usual cars. Military and special cars, particularly all those fitted with radios, require additional suppressing devices. Investigations up to 1 GHz have been carried out; other investigations within the same frequency bands are expected for naval ignition motors and, if necessary, for diesel motors in general. A review paper on this subject is contained in this same issue. Nothing outstanding in noise suppression can be expected in the near future, in spite of the increasing extension of electronic ignition systems.

Broadcast radio and television and any other type of receivers (CISPR SC E) have been and are presently studied and investigated as radiation sources. Cheap suppression means have been adopted since long time, both concerning local oscillator radiation and time-base noise (for television receivers). Increasing diffusion of colour television sets has increased the latter type of noise, due to the noticeable jokes deflection current (1 A_{peak} and more); extension up to 30 MHz is under consideration. Limits and methods have been established by CISPR in cooperation with IEC. For local oscillator voltage at the antenna terminals, a modification is expected, particularly with restriction of the limits, due to a thicker allocation of channels in the community television distribution systems and requests for protection of aeronautical services coming from ICAO.

Moreover, another aspect not yet sufficiently studied and investigated is the so called "immunity", that is the protection of the receiver set against the surrounding noise fields.

Appreciable contributions appeared recently on this subject, concerning methods of measurement and suppressors; limits are still under consideration, except for the less significant cases. Progress is desired and expected to some extent in the near future.

Components for the community television systems are being investigated and since they include amplifiers, converters, transformers, screens and cables, there is room for contributions by electromagnetic theorists, particularly for the last two items.

Other different types of noise sources are commonly assembled under the general heading of domestic appliances (CISPR SC F), as they include: washing machines, vacuum cleaners, thermostatized irons, freezers, hair driers, luminaires, triacs and similar devices. Noise results here from the combination of the commutator low frequency transients and the single switches transients: suppressors devices have been developed and the limits have been established on account of the recurrence frequency and spark amplitude. Here also abatement of noise is typically an economic problem: the present limits are not expected to be reduced in the near future, except possibly for triacs, that are responsible at present for an excessive noise level on long wave broadcasting.

Finally, data processing equipment and electric office machines are now under investigation, as they can interfere the same and other machines and produce erroneous results. Many problems, including electrostatic discharges, are open in this field. CISPR has entrusted all these problems to SC B.

Studies on the applications of statistical methods concern SC A.

Basic instruments for the noise measurement are typically special voltmeters specified by conventions (peak, quasi-peak, average, r.m.s.) and the spectrum analyzers. Digital instrumentation has been introduced with success, particularly in order to meet the recommended procedures for washing machines and similar devices containing timers and program control; new types of instruments are in progress of designing and manufacturing in laboratories and industrial organizations.

Accordingly, antennas and associated structures have been developed, in order to convert the voltmeter into a field intensity meter, taking into account the matching devices. Simplifications of the antennas are often required when field measurements are being carried on. These are made in order to avoid (for instance) poor or uncertain contacts, as in the case of variable length dipoles, and variability of electric center, as in the case of logaritmic antennas, practically unusable at the reduced distances prescribed in many CISPR Recommendations. Measurements of the vector $\bar{E}$ through a system of three orthogonal dipoles embedded in a spheric enclosure, are being carried on with satisfactory results for very strong fields (some volts/meter and more).

Another interesting and promising field of investigations is that of a space with constant and controllable field intensity, in view of investigating immunity of receivers and other low level V.H.F. and audio devices. Difficulties are encountered particularly when the dimensions of the set under test are comparable with the wavelength: this is again a good investigation area for theorists in electromagnetism, as shown in some recent international symposia.

The set-ups under study to generate such nearly uniform intensity spaces can be fed by generators of various waveforms, according to the interference model that is to be realized in the different cases. A rather new field of research is the so-called EMP (electromagnetic pulses), particularly interesting for the aeronautical immunity tests.

3. SUBJECTS OF THE PAPERS CONTAINED IN THIS ISSUE

The "call for papers" concerning this special issue was published in the February 1979 issue of ALTA FREQUENZA and was splitted into the two main subjects effectively considered here. This information was also given during the last EMC Symposium, held in Rotterdam from the first to the third of May 1979.

The regular and high rate of Meetings and publications of specialized Reviews could have the consequence of exhausting the main available sources; nevertheless, some good subjects were found by the Authors of the papers collected in this issue, that touch mainly radiation problems.

The contributions can be subdivided as follows:

EMP
- V. Carpegna and M. Mensa: The study of an EMP dipole antenna simulator.
- G. Franceschetti: Transient electromagnetic fields in a cylindrical enclosure.

ENVIRONMENT
- G. Lari: Problems concerning the surroundings of sound and TV broadcasting stations.

IMMUNITY
- B. Audone and M. Mensa: The use of TEM lines in electromagnetic compatibility tests.

MEASUREMENTS AND INSTRUMENTATION
- L. Bolla and G. Gerbi: An electric and magnetic field-meter.
- P. Corona: Electromagnetic reverberating enclosures: behaviour and applications.
- M. Borsero, L. Brunetti, and P.G. Galliano: International calibration cycles of field intensity and power density.
- M. Borsero and E. Nano: Test site suitability assessment for radiation measurements.

SHIELDING
- P.L.E. Uslenghi and J.E. Bridges: Theory of electromagnetic field penetration through the shield of a coaxial cable.

SOURCES OF INTERFERENCE
- C. Egidi, P.G. Galliano, and E. Nano: R.F. emission from motor vehicles.

It is the hope of the Review ALTA FREQUENZA to stimulate other studies and experiments, mainly from researchers and technicians working in the electromagnetism area, considering the increasing importance of their possible contribution in solving theoretical and experimental EMC problems.

ACKNOWLEDGEMENTS

The reviewing of this paper by Messrs. P.G. Galliano, E. Nano, J. Meyer de Stadelhofen, and R. Cortina is much appreciated.

Radio, TV Broadcasting Hazards

Milan ALTA FREQUENZA in English Mar-Apr 80 pp 139-141

[Article by Guido Lari, of Rai-Radiotelevisione Italiana, Roma: "Problems Concerning the Surroundings of Sound and TV Broadcasting Stations"]

[Text] *Abstract.* The text analyses the problems which arise from the co-existance of human activities and the presence of sound and TV broadcasting stations including radio-relay link stations. These problems are more or less important according to the frequencies and power employed and according to the different environmental situations. The siting of certain stations, especially the high power ones, should be evaluated in the framework of territory planning.

1. INTRODUCTION

The industrial and urban expansion carried out over the past few years has raised different types of problems concerning the compatibility between sound and TV broadcasting stations and radio-relay links with regard to the surroundings.

The most serious problems occur when the environment is substantially modified, causing conditions which reduce efficiency and consequently the service provided.

Some of these problems that may sometimes occur simultaneously, are specified below.

2. DAMAGE THAT THE TRANSMITTING STATIONS MAY CAUSE TO A THIRD PARTY (PEOPLE AND/OR THINGS)

Taking into consideration the location of the transmitting antennae and the power level used so far, direct exposure to e.m. radiation does not seem to cause harmful effects on people, at least according to the legal standards observed in other countries within the E.B.U.[1] In Italy, the problem is under investigation by the "Istituto Superiore di Sanità" (Italian Government Health Institute) and other Organizations.

However the following situations may be considered as probable:

a) danger to people due to accidental contact or during work with metallic parts where high current is induced by radio frequency of considerable amplitude because of the vicinity of transmitting antennae;
b) danger to people due to accidental fire or the explosion of some materials caused by currents induced by radio-frequency;
c) the impossibility of performing some works near the transmitting stations, due to inconveniences or disturbances that could be caused by e.m. fields, e.g. especially on electric and electronic equipment, even though no danger to people exists;
d) area restrictions near the masts that comprise or support the radiating systems as a result of the possibility of:
    - material falling during maintenance, modification, painting;
    - large ice blocks that could fall during the

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[1] The European Broadcasting Union.

winter season;
- lightening which could have direct or indirect effects.

3. DAMAGE THAT THE MODIFICATION OF SURROUNDINGS MAY CAUSE TO SOUND AND TV BROADCASTING STATIONS

The modification of the surroundings of existing transmitting stations as well as the construction of new buildings or the excessive growth of vegetation could result in:

a) the absorption and/or deviation of the radiating power causing a reduction in the service provided by the stations;
b) the partial or total reduction of the efficiency of radio-relay links;
c) the impossibility of increasing or modifying the installations.

4. LIMITATIONS DETERMINED BY PARTICULAR ENVIRONMENTAL CONDITIONS

Some considerations of a legal nature must be taken into account during the Planning of the installations since they might later restrict or preclude further modifications, for example:

a) protection of the landscape;
b) the presence of other activities that might by law impose limitations, for example, airports, large electric lines, etc.;
c) perimetral areas necessary to protect those stations subject to frequent bush fires;
d) territorial limitations and/or limitations imposed by the Municipality.

5. EXAMINATION OF INCOMPATIBILITIES

Transmitting stations in bands 5, 6 and 7 as well as radio-relay link stations (althoung these present different types of problems) are more subject to variations of the environment and, at the same time, are capable of conditioning it.

5.1. Transmitting Stations (bands 5, 6 and 7)

As far as harm to people is concerned - at least in Italy - there is no evidence to date that any serious damage from radio-frequency induced currents exists for those living in the general vicinity. However, one should not exclude this danger in particular circumstances, especially in areas closely located to stations utilizing the highest powers.

Generally, radio-frequency induced currents on metallic structures can cause physical discomfort on contact and metallic equipment, in buildings of reinforced concrete structures and long external pipelines.

In order to eliminate or reduce the risks of these phenomena, some precautionary measures should be taken, such as the use of insulating gloves, careful grounding, substitutions of metallic wires by insulating ropes, sectioning of all metallic groundings with insulating joints.

Other inconveniences of electrical equipment, (for example, the continuous lighting of lamps, either in households or streets, telephone equipment, TV and radio sets etc.   due to the presence of undesirable radiophonic modulation during the use of this apparatus), can generally be eliminated by inserting filter condensers or by taking other suitable technical measures.

Moreover, the presence of large transmitting stations can affect certain activities besides those where people are exposed to danger, for example, in the electronics industry or in storage plants for inflammables or explosives.

In the first case, we must consider the difficulties involved in the construction or use of the apparatus (especially measurement instrumentation and electronic computers) which could be eliminated by appropriately shielded rooms; in the second case, there is a risk of sparking due to induced currents in the wires; in the third case, there is the possibility of fire indirectly caused by flashover resulting from induced voltages between structures or metallic parts that have not been sufficiently grounded.

As regards the service areas of the transmitters, two kinds of phenomena may occur when the transmitter site originally surrounded by an agricultural area is modified because of the construction of industrial or civil buildings too closely crowded together. Both phenomena tend to reduce the efficiency of the stations either from the point of view of the ground wave service or the sky wave service. These phenomena can produce:

- the degradation of the electric characteristics of the soil and subsequent loss in propagation;
- the direct absorption of power by metallic vertical structures located very close to the transmitting antennae together with phenomena of re-radiation modifying the radiation pattern of the antennae.

Moreover, as concerns transmissions in band 7 (HF) it should be pointed out that situations ensuring the proper reflexion of e.m. waves are necessary in the "Fresnel zone", which in some cases can extend for some kilometers from the antennae.

The presence of many buildings or forests, as well as the formation of quarries, which can vary the altimetric profile, cause a deviation of the radiating lobe, resulting in serious power losses in the desired direction (even those over 6 dB).

5.2. Radio-relay link stations

Problems of radio-relay link stations only affect the use of links that could be obstructed or limited either because of the growth of vegetation or, above all, by building constructions along the link paths, that could intercept or reflect the reception or transmission signals.

5.3. FM and TV stations (bands 8 and 9)

These stations normally situated in a high position use antennae whose directional characteristics avoid the concentration of e.m. energy in the immediate surroundings of the station. Taking into account the kind of propagation used, the problems almost exclusively concern the possibility of causing damage to a third party, either in the risk of sparking electric detonators which could occur only under special circumstances, and namely, if the area where detonators are used (for example an open mine) is struck by strong e.m. fields or as regards the risks mentioned in item 2d.

6. CONCLUSIONS

From the above, the close interconnections between sound and TV broadcasting stations and the environment are obvious.

The most critical situations occur in existing installations. In fact, even if the technical measures we have already suggested solve a large number of situations, one should bear in mind that they cannot always be adopted in an overall, favourable and permanent manner.

However, an increase in the radiated power or a relocation of the transmitting stations would seem, at first sight, the easiest solutions in order to re-establish certain situations or to solve incompatibility problems.

As concerns the first solution, the state of the spectrum occupation and international rules, with regard to the precise links existing among all the stations, prohibit the employment of a power increase of the transmitters without considering that this fact could cause other problems.

Apart from the high cost involved, the second solution cannot always be adopted since, besides difficulties in finding new sites which fulfill all the technical requirements, sometimes quite insurmountable, there is inevitably the necessity to modify the characteristics of the stations in accordance with the international limits mentioned above. In any case, relocation could have a negative effect on radio and TV users, particularly in the case of a TV station; users would have to at least modify the antenna orientation or even replace the receiving antenna at a high cost for the community.

In addition to provisions in the "Italian Postal and Telecommunications Code", it would be convenient, whenever possible, for the sound and TV broadcasting stations to be appropriately protected in order to guarantee a public service that must be included in the territorial development Plan. This is also valid when considering general economic criteria.

Considering multiple differences in the characteristics of the transmitting stations (location, orientation, height and type of antennae, radiated power, shape of the servoce area, linked paths, etc.) general criteria cannot always be establisned. In some cases, special criteria must be establisned according to the development of the areas concerned.

In reference, as concerns probably damage to a third party and limitedly to A.M. stations in band 6 (MF) our experience shows that a low power station (up ot 2 kW) can be situated in the centre of a town, but that some effects could result from a 100 kW station at distances up to 500 m from the transmitting aerial. These effects lose their importance at a distance of over a kilometer.

Concerning the efficiency of the service carried out by the station (exception is made for urban low-power A.M. transmitters in band 6, local service) a surrounding agricultural area or with a few buildings is needed, along with the necessity of being relatively close to the main urban area in order to ensure good service.

As to the radio-relay link stations, in order to be certain of the efficiency of the service, it is necessary to maintain an area free from any obstacles. The dimensions of this area surrounding the path between terminal stations of the link depending on the frequency, the path length and the position of the antennae.

Moreover, in order to eliminate the reflection phenomena, it is absolutely necessary to limit construction within a certain range and at a certain angle in the immediate vicinity of the link station.

These phenomena are more harmful to the quality of the service the closer the reflecting obstacle is to the station and to the axis of the link.

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Electromagnetic Field Radiation Measurements

Milan ALTA FREQUENZA in English Mar-Apr 80 pp 150-153

[Article by Luciano Bolla, Giuseppe Gerbi, of Aeritalia, Settore Avionica, Torino: "An Electric and Magnetic Field Meter"]

[Text] *Abstract* . The problem of quantifying hazardous electromagnetic field is difficult because measuring sites are often at points close to powerful RF sources or where arbitrary polarization and multipath interference exist.
The RF field measuring equipments are usually based on simple planewave field propagation assumption that is inadequate for complicated fields and could give tangible errors in many cases.
Therefore it is generally considered more correct to measure electric and magnetic field strenghts separately instead of power density. An isotropic RF electric/magnetic field strength meter has been developed in order to meet requirements for both near and far field measurements.
Some other concepts such as operability, affidability and solidity have been taken into account designing this measuring equipment which is intended for both laboratory and field applications.

1. INTRODUCTION

During these last years the problem of quantifying electromagnetic fields with special attention paid to Radiation Hazard has become more stringent because of the increased intensity and frequency occupancy of radiating sources.

Although there are no clear and simple cause-effect relationships in the area of radiation hazard and a unique agreed limit does not exist it seems quite important to be able to determine the areas where the radiation level is high in order to take protective measures.

Therefore it is necessary to get suitable instruments to measure those parameters characterizing the electromagnetic field radiation hazard correctly.

2. SYSTEM DESIGN

The design of a measuring equipment dedicated to the measurements of strong field strengths should take into account the following aspects arising from practical experience and from theoretical considerations.

a) Biological aspect

Electromagnetic hazards are not strictly related to the energy or power density in space but rather to the fields inside subjects and to the absorption of fields by biological tissue. Energy absorption of fields by biological tissue. Energy absorption by the biological tissue, produces a temperature rise that can be measured by a number of existing temperature sensors of small size applied to the subject. However there are many difficulties in the practical execution of such a type of measurement and moreover considerable controversies exist over whether mere temperature effect is the only and more important parameter to judge the hazard associated to the EM fields. Therefore, it is generally retained more satisfactory to base measurement on the internal electromagnetic field rather than on temperature rise.

Since the hazard is determined by the field inside the subject the obvious procedure should be the measurement of the field inside a phantom simulating the subject. However there are many difficulties to simulate the geometrical and electrical characteristics of the subject submitted to the hazard fields and on the other hand these types of sensors will never be practical enough for hazard-survey meters. At the moment the unique solution seems to be the measurement of the electromagnetic field in the absence of the subject and then to take into account the subject simulating the biological tissue with some mathematical model.

The sensor design of the developed metering instrument follows this guide line. However, a sensor providing the simulation of actual subjects (a ball of a particular material containing the probe that simulates the electrical characteristic of tissue) could conceivably be practical for a hazard-survey meter and is at the moment under study.

b) Measurement consideration

For a simple plane wave, any one of a number of field parameters ($|E|$, $|H|$, power density) constitutes a valid index to specify the field (apart from phase, polarization and direction).

$$|E| \,/\, |H| = |Zm|$$

$$P = \frac{1}{2}\,|H|^2\,|\mathrm{Re}\ Zm| = \frac{1}{2}\,|E|^2 \,/\, |\mathrm{Re}\ Zm|$$

For arbitrary or near fields the above relationships are not longer valid and the following problems arise:

- power density measurements executed with probes sensitive to the electric or magnetic field components and assuming free-space conditions could be grossly incorrect.
- in any case the effective power density is not a good measure of the hazard of RF radiation (in the reactive zone the time-average power density can be low, electric and magnetic fields arbitrarly large)
- it should be necessary to measure the parameter most appropriate and closely related to the hazard associated to the EM fields.

For this purpose the energy density should be an adeguate parameter that, for a generical material, is expressed by the relationship:

$$\frac{1}{2}\left[(\bar{\varepsilon}\cdot\bar{E})\,\bar{E} + (\bar{\mu}\cdot\bar{H})\,\bar{H}\right]$$

In the simplified case of homogeneous, linear and isotropic material the energy absorption is proportional to $\varepsilon|E|^2$ and $\mu|H|^2$. Such assumptions to obtain this simple proportionality are obviously not realistic for a biological tissue, however the result suggests the use of single real scalar parameters ($|E|^2$ and $|H|^2$) for radiation hazard standards and survey measurements [1]. $|E|^2$ and $|H|^2$ parameters represent a good choice to measure correctly the EM hazard because are always valid (in near or in far field) and might represent a stable starting point for more complex considerations. Because the biological materials are essentially not magnetic the hazard due to EM fields should be usually most closely related to $|E|^2$ and the measurement of $|H|^2$ is expected to play a secondary role.

c) Polarization, multipath, interactions

Practical situations involve propagation of two or more fields at different frequencies in the same region, scattering, reflection or interaction with surrounding objects establishing multipath interference, unknown or complicated polarization of the field. To take into account polarization (polarization may change radically from point to point in the case of industrial heaters) and multipath effects (multipath interference may be due to scattering with objects located near the source or caused by two or more sources operating at the same frequency) the measuring equipment should be sensitive to EM fields incident from all directions. Besides, to avoid scattering problems by itself, a good general purpose equipment should have the size of the field sensors smaller than the shortest wavelength of interest. In many cases it is required to perform measurements near metallic objects or in limited sites where coupling between the probe and the close material might produce errors; to reduce the coupling with surrounding objects the probe should be balanced.

3. ELECTRIC SENSOR

Three electric sensors have been designed in the source frequency range 1 - 500 MHz for three full scale indications of 10-100-1000 V/m. The electric probe is a dipole antenna shorter than the wavelengths corresponding to the frequency range of interest. The isotropic diagram is achieved by means of three mutually perpendicular dipole antennas. The signal detected by the antenna is rectified by a diode shunted by a capacitor necessary to maintain a constant frequency response [2] .

The outputs of the three antennas constituting the sensor are connected in series; therefore the output voltage is proportional to:

$$|E|^2 = |E_x|^2 + |E_y|^2 + |E_z|^2$$

The design optimization has been achieved by means of the computer aided approach based on the mathematical model of Fig. 1.

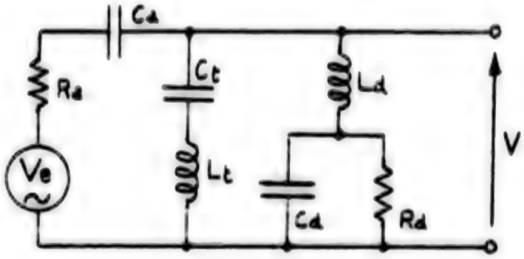

Fig. 1. Model used in the optimization process: electric dipole.

In the model used the antenna parameters are [3]:

$$R_a = \frac{20\pi^2\, l^2}{\lambda^2}$$

$$C_a = \frac{l/c}{120 \ln 2l/a}\;\frac{tg\, \beta l/2}{\beta l/2}$$

where: l is the half antenna length
a is the antenna conductors radius

The diode dynamic resistance Rd has been measured experimentally; this parameter is particularly important in establishing the frequency response of the system. The results of the simulation are shown in Fig. 2 for the three types of sensors.

The computer aided approach has been very useful in the optimization of the sensor design from the point of view of sensivity and broadband frequency response.

4. MAGNETIC SENSOR

Two magnetic sensors have been designed in the frequency range 1 MHz - 100 MHz for full scale indication of 1 A/m and 10 A/m. The magnetic probe is a loop antenna with one or more turns as a compromise between sensitivity and broadband response. The isotropic diagram is achieved by means of three mutually perpendicular loop antennas. Similarly to the electric field sensor the signal detected by the antennas is rectified by a diode.

The outputs of the three antenna constituting the sensor are connected in series; therefore the output voltage is proportional to:

$$|H|^2 = |H_x|^2 + |H_y|^2 + |H_z|^2$$

Again the design optimization has been achieved by means of the computer aided approach based upon the mathematical model of Fig. 3. The R1-C1 group is necessary to introduce a pole in the frequency characteristic of the loop antenna in order to achieve a flat response.

The values of the elements of the equivalent loop antenna have been determined with both theoretical considerations and practical measurements. The final result of the design is shown in Fig. 4.

5. CALIBRATION OF SENSOR

TEM transmission lines have been used to calibrate both electric and magnetic sensors. The TEM line generates a uniform standard electromagnetic field easily known by the measurement of voltage or power at the load; magnetic and electric fields are related by the free space impedance.

For the performance of a highly accurate calibration the TEM transmission line has been mathematically modelled on the computer as a line with discontinuities physically located at input and output connectors [4] . The result of this analysis has been the definition of the exact field along the central plate of the TEM line produced

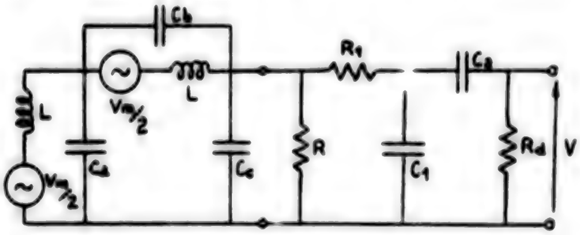

Fig. 3. Model used in the optimization process: magnetic antenna with two turns.

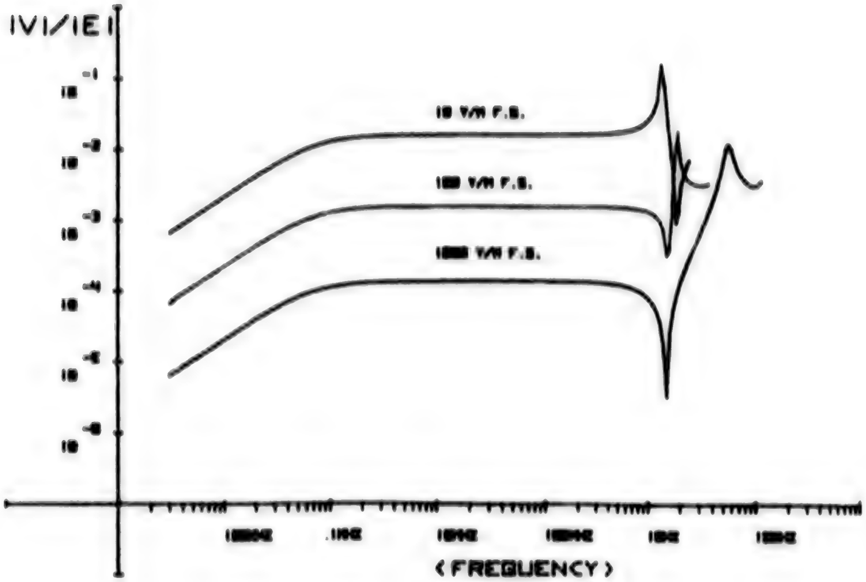

Fig. 2. Electric sensor transfer functions

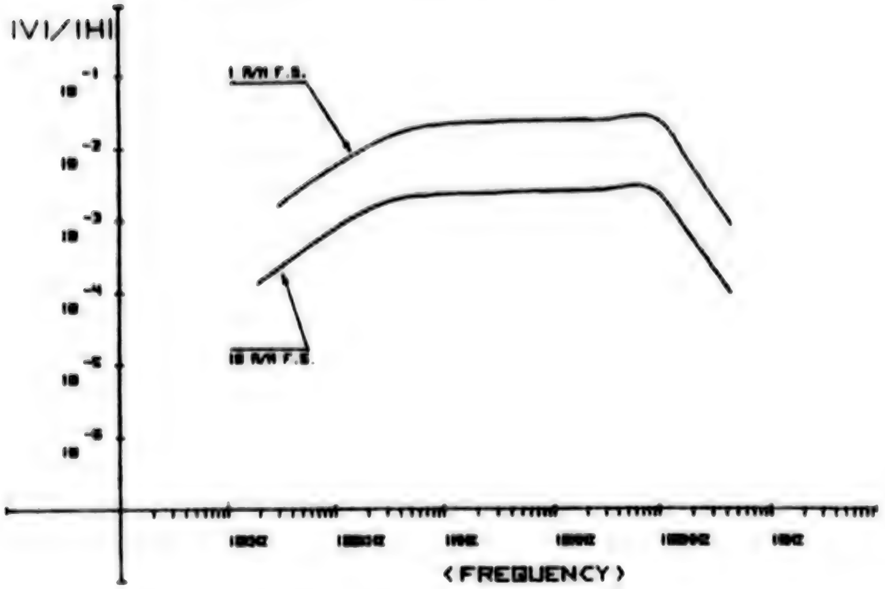

Fig. 4. Magnetic sensor transfer functions

by the fundamental mode as function of frequency. In Fig. 5 the normalized electric field as function of the normalized length and of frequency used for calibration is shown.

6. METER AND REPEATER DESCRIPTION

The metering instrument can accept all the five isotropic sensors. In order to reduce the thermal drift and to avoid an external zero offset trimmer a high quality chopper amplifier has been used. An analog square rooter produces an output directly proportional to the electric or magnetic field allowing to have a linear definition on the scale of the indicator instrument. The signal is also applied to a voltage controlled oscillator driving an infrared light emitting diode for the fiber optic link connected to the repeater equipment.

The repeater equipment, converts incoming infrared light pulse frequency into analog voltage which is applied to the indicator repeater.

The active internal components are feeded by a stabilized DC/DC converter.

An analog output connector is available on the repeater giving the possibility of connecting a recording instrument.

7. CONCLUSION

At the moment an effort is made to design other sensors at lower and upper frequencies to cover the frequency range 10 KHz - 18 GHz. A study is also carried out to improve the calibration technique.

Acknowledgement

The authors want to express their gratitude to Mr. B. AUDONE for his fruitfull suggestion.

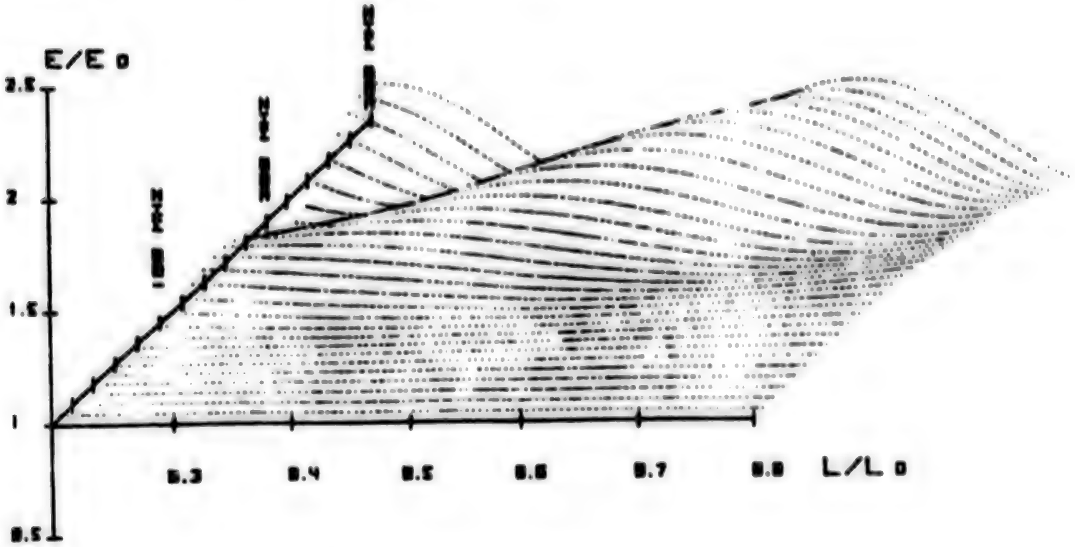

Fig. 5. Electric field in the TEM line

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Electromagnetic Reverberating Enclosure Measurements

Milan ALTA FREQUENZA in English Mar-Apr 80 pp 154-158

[Article by Paolo Corona, of Istituto Universitario Navale, Napoli: "Electromagnetic Reverberating Enclosures: Behavior and Applications"]

[Text] *Abstract.* The increasing needs of accurate measurement of total emitted or absorbed electromagnetic power for normative purposes can be in some cases fulfilled by means of reverberating enclosures. The basic principle is that in a large (in terms of wavelenght) cavity, the modal structure of the electromagnetic field can be averaged by means of mode stirrers, obtaining an average uniform field distribution whose level is related to the total feeding power. Applications and calibration procedure are referred. Comparison of various chambers, both at our laboratories and in different countries is done through experimental data analysis. Outline of various applications is made. A complete analysis of related parameters is carried out, in order to give some understanding of chambers behaviour.

1. FOREWORD

In Electromagnetic Compatibility measurements, as well as in the evaluation of biological effects of electromagnetic radiation, there is a need of some standard electromagnetic environment which acts as a reference.

Usually reference is made to a plane, uniform wave. From pratical point of view, such wave can be obtained only by means of a source at relatively large distance in a reflection free environment, or by means of very large equiphase radiator (as parabolic reflectors or lenses): both arrangements, but namely the first one, are unable to furnish high level fields, as requested for EMC and biological applications. Furthermore theoretical evaluation of experimental data results in a scattering problem which cannot usually be solved, not even by means of numerical techniques.

In recent years some new measuring techniques were developed which make use of confined fields (usually in conductive enclosures), and it is now evident that they can be an useful alternative to the traditional "plane wave" approach.

A good overview of these techniques is in [1]: among them there are mode stirred chambers.

Purpose of the present paper is to compare experimental results of recently built reverberating (mode stirred) chambers, which allow quick and reliable measurements of absorbed and emitted power without passing through the cumbersome (and less reliable) field evaluation.

2. MODE STIRRED (REVERBERATING) CHAMBERS

A mode stirred chamber is a large (in terms of wavelength) cavity whose boundary condition are continuously and randomly perturbed by means of (rotating) conductive stirrers. Inside such a cavity the average field can be assumed uniform (in level) and formed by uniformly distributed plane waves [2,3,4,5,6,7] .

Furthermore, a power balance can be stated [8], [9] and measured, so that power dosimetry, both for emission and absorption, becames extremely easy. Various applications are in use or proposed [10, 11, 12, 13, 14].

The measuring technique appears so reliable at higher (GHz) frequency that it seems possible to decrease the operating frequency down to the frequency bands of few hundreds of MHz, where most compatibility problems arise; and some reverberating chambers are already in use in these bands.

In consideration that losses play an essential role in mode stirred chamber consequently any physical scaling procedure cannot be applied. It seems advisable to develop a careful analysis of performance of available chambers, in order to assess some useful parameters for further constructions.

3. REVERBERATING CHAMBERS PERFORMANCES

At the present time, in the author's knowledge, data referring to seven chambers are available in literature or from the people who have constructed them. Their geometry is summarized in table I.

Some of them where built expressly as reverberating chambers and their walls are aluminium. Some have been constructed by modifying shielded rooms which usually have steel walls.

A fast way to get useful informations about a reverberating chamber behaviour is to measure its insertion loss [15] : (fig.1). A direct comparison of results is related both to frequency behaviour and to measuring technique employed to evaluate the insertion loss. This last is not straightforward, because statistical parameters are involved [16] . In any case results referred in fig. 1 will be employed to assess some parameters in next section.

4. PARAMETERS INVOLVED IN REVERBERATING CHAMBERS BEHAVIOUR.

Inside a reverberating chamber, the E.M. field can be assumed to be due to a succession of independent steady state fields; this is mainly due to the very slow (referred to the electromagnetics) stirrer speed. Therefore parameters pertaining to fixed geometry cavities can be computed as usual, but measured data will compare with average of such parameters.

Up now statistical analysis of received signal was carried out [4, 17], but no comparison was made to internal, steady state, parameters.

According to large E.M. cavities theory we can compute: the quality factor Q: (see e.g.[18])

$$Q \approx \frac{V}{S\,\delta} \tag{1}$$

The mode number N: [19]

$$N \approx \frac{4\pi}{3}\;\frac{V}{\lambda^3} \tag{2}$$

The mode density

$$\frac{dN}{df} \approx \frac{4\pi}{f}\;\frac{V}{\lambda^3} \tag{3}$$

Furthermore, it is possible to evaluate an average quality factor Q' [8, 9] from the measured insertion loss Pr/Pt:

$$Q' = 16\pi^2\frac{V}{\lambda^3}\;\frac{Pr}{Pt} \tag{4}$$

In all the above formulae:
S = cavity internal surface
V = cavity volume
λ = wavelength
f = frequency
δ = skin depth.

In table II data obtained by means of (1), (2), (3), (4) and fig. 1 are listed: apart that all the forms are roughly approximate (in (1) a form factor has been dropped: (2) and (3) are valid only for large N), some more explanation is required.

The Q value computed by means of (1) has to be accepted only as an upper-bound value, because it does not take into account any losses other than due to wall conductivity. For some chambers probably most losses are by far due to leakage [8] . The Q' value computed by means of (4) is directly related to the insertion loss Pr/Pt (fig.1), but (4) is based on the assumption of continous mode coverage.

In order to give more details about this point we have to refer to the average modal distance (in terms of frequency): which is the reciprocal of the mode density (3).

$$\frac{df}{dN} \approx \frac{f}{4\pi}\;\frac{\lambda^3}{V} \tag{5}$$

If we assume a continous modal coverage, the bandwidth of each mode has to be larger than modal distance,

$$\frac{df}{dN} < \frac{f}{Q_e} \tag{6}$$

where Q_e is the effective quality factor of the mode; from (5) and (6)

$$Q_e < f\,\frac{dN}{df} \approx 4\pi\frac{V}{\lambda^3} \tag{7}$$

but $Q_e < Q$ so that (7) is fulfilled if(table II)

$$Q < f\,\frac{dN}{df} \approx 4\pi\;\frac{V}{\lambda^3} \tag{8}$$

otherwise the "geometry modulation" (due to stirring technique) sweeps the frequency range; under the assumption of linear dependence of the resonance frequency versus the geometry stirring, we can assume an "occupation ratio" R, equal to the ratio of the mode bandwidth to the mode distance (in frequency):

$$(9) \qquad R = \frac{f/Q_e}{df/dN} = \frac{1}{Q_e} \; 8\pi \, \frac{V}{\lambda^3}$$

From table II it is evident that mainly at lower frequencies when (9) is not fulfilled, Q' differs from Q_e by weight factor R which can easily reach an order of magnitude or more.

In summing up, the effective value (Q_e) of quality factor is usually lower than the computed one (Q), mainly because of the leakage and additional losses. Furthermore, when (8) is not fulfilled the measured value (Q') is less than the effective value (Q_e) by factor R. Following the previous analysis we can advance these suppositions:

(a) For both IUN, and for JMI chambers, most of the discrepancy between Q and Q' is due to leakage loss; and up now we have no model to compute it.

(b) For Litton and Harry chambers the discrepancy is mainly due to additional loss introduced by wall paint and floor structure (both were made by modifying existing shielded rooms).

(c) For both McDonnellchambers, which are very tightly built and consequently have very small leakage loss, discrepancies arise mainly at lower frequencies, where modal coverage does not allow the use of (4). Discrepancies can be, in these cases, reduced by introducing a weight factor R, according to (9).

5. CONCLUSIONS

Experimental data relative to various mode stirred rooms are referred. A simplified analysis, based on forms valid for large cavities has been carried out, even from a modal point of view. Making use of this appoach both experimental and theoretical data are compared in order to give more insight on the physical behaviour of stirred cavities, hypothesis are suggested in order to justify the larger discrepancies.

TABLE I

	VOLUME m^3	INTERNAL SURFACE m^2	MATERIAL	OTHERS
IUN/OEM	8	24	Aluminium	Large Leakage
"	1	6	"	" "
LITTON	22	48	Steel	Modified shielded room
JMI	8	24	Aluminium	
MDAC	54	98	"	Very low leakage
"	1.2	7	"	" " "
U.K.	22	48 +	Steel +	Modified shielded room

(+) Estimated data.

DATA VAILABILITY

IUN/OEM	from the author.
LITTON	from H. C. Anderson or R. R. lentz - Litton - Minneapolis.
JMI	from M. Okamura or S. Miyama - JMI - Tokyo.
MDAC	from J. M. Roe - McDonnell Douglas - St. Louis.
U.K.	from Harry - U.K. through CISPR.

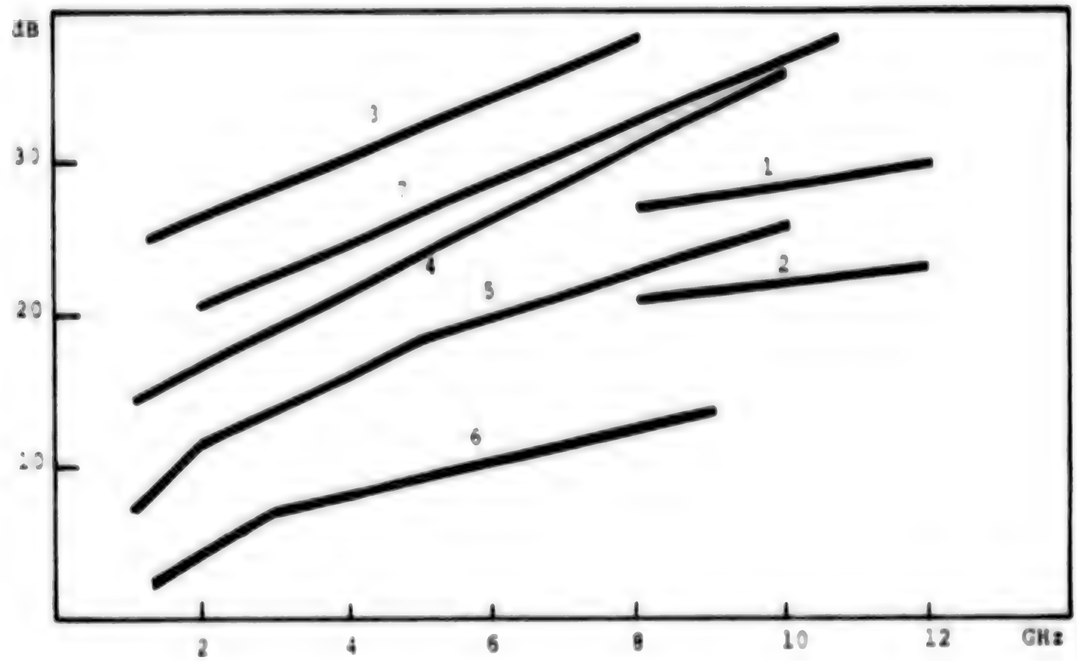

Fig. 1 - Insertion losses of various reverberating chambers.
1. 2: IUN/OEM chambers. - 3: Litton chamber. - 4: JMI chamber.
- 7: Harry (U.K.) chamber.

TABLE II

	f (GHz)	2	4	6	8	10	12
IUN (8m ^{3})	Q ($\times 10^{-4}$)				36	40	44
	Q' ($\times 10^{-4}$)				4.8	5.9	8.1
	N ($\times 10^{-6}$)				.64	1.2	2.1
	dN/df ($\times 10^{6}$)				238	372	536
	f dN/df ($\times 10^{-4}$)				190	372	643
IUN (1m ^{3})	Q ($\times 10^{-4}$)				18	20	22
	Q' ($\times 10^{-4}$)				2.4	3.7	5.0
	N ($\times 10^{-6}$)				.08	.15	.27
	dN/df ($\times 10^{6}$)				30	46	67
	f dN/df ($\times 10^{-4}$)				24	46	80
JMI	Q ($\times 10^{-4}$)	18	25	36	40		
	Q' ($\times 10^{-4}$)	.75	1.8	2.5	1.9	1.5	
	N ($\times 10^{-6}$)	.01	.08	.27	.64	1.2	
	dN/df ($\times 10^{6}$)	15	60	134	238	372	
	f dN/df ($\times 10^{-4}$)	3	24	80	190	372	
MDAC (54m ^{3})	Q ($\times 10^{-4}$)	30	42	51	59	67	
	Q' ($\times 10^{-4}$)	16	50	68	81	79	
	N ($\times 10^{-6}$)	.07	.53	1.8	4.2	8.4	
	dN/df ($\times 10^{6}$)	100	402	904	1608	2513	
	f dN/df ($\times 10^{-4}$)	20	160	542	1268	2513	
MDAC (1.2m ^{3})	Q ($\times 10^{-4}$)	9	13	16	19		
	Q' ($\times 10^{-4}$)	1.7	7	13	20		
	N ($\times 10^{-6}$)	.001	.01	.04	.10		
	dN/df ($\times 10^{6}$)	2	9	20	36		
	f dN/df ($\times 10^{-4}$)	.4	3.6	12	29		
Litton	Q ($\times 10^{-4}$)	13	18	22	26		
	Q' ($\times 10^{-4}$)	.2	.8	1.1	1.0		
	N ($\times 10^{-6}$)	.03	.2	.7	1.7		
	dN/df ($\times 10^{6}$)	41	163	368	655		
	f dN/df ($\times 10^{-4}$)	8.2	65	221	524		
Harry (U.K.)	Q ($\times 10^{-4}$)	13	18	22	26	29	
	Q' ($\times 10^{-4}$)	1.0	2.6	3.9	3.7	3.3	
	N ($\times 10^{-6}$)	.03	.2	.7	1.7	3.4	
	dN/df ($\times 10^{6}$)	41	163	368	655	1023	
	f dN/df ($\times 10^{-4}$)	8.2	65	221	524	1023	

all data in MKS units

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Field, Power Intensity Calibrations

Milan ALTA FREQUENZA in English Mar-Apr 80 pp 159-162

[Article by Michele Borsero, Luciano Brunetti, Pier Giorgio Galliano, of Istituto Elettrotecnico Nazionale Galileo Ferraris, Torino: "International Calibration Cycles of Field Intensity and Power Density"]

[Text]

ABSTRACT

Field intensity measurements, up to 400 MHz, and power density measurements, above 400 MHz, has become rather important, due to the worldwide interest about the study of electromagnetic compatibility and nonionizing radiation interactions with biological systems.

Traditional measurement techniques are affected by inadequate accuracy; at best field intensity measurements are performed with an uncertainty of about ± 3 dB.

Two international calibration cycles, on field intensity and power density, have been performed during the last two years.

Instrumentation and measurement techniques used to perform these calibration cycles are described.

INTRODUCTION

While the measurement accuracy of most electrical quantities has shown a continuous improvement in the last ten years, for the electric and magnetic components of a radiofrequency electromagnetic field, however, no significant amelioration has been achieved. Indeed these are the electrical quantities measured with the lowest accuracy at present.

This is due to various causes, e.g. the perturbations produced by the measuring device, i.e. the antenna, on the measured element, i.e. the electromagnetic field, and the environmental conditions which may be different every time.

Another element which affects the overall uncertainty is the measurement of the antenna voltage. This measurement is generally performed at frequencies higher than 10 kHz by special selective voltmeters (field intensity meters) whose uncertainty is about ± 1 dB.

Radiofrequency voltage measurements may be carried out with higher accuracy but by means of instruments not suitable for use in the open air.

Recently there has been a higher interest in this type of measurement and in the development of apparatus and sensors which give rise to a smaller field perturbation and consequently to a higher measurement accuracy.

This is also due to the spreading acknowledgment that very intense electromagnetic nonionizing radiations can produce harmful effects on biological systems.

In order to obtain information both about the field intensity and power density measurement accuracy, and about the uncertainty of the results obtained by standards laboratories, two international intercomparison cycles have been carried out.

The international intercomparison cycles are organized by the Working Group on radiofrequency quantities of the CCE ("Comité Consultatif d'Electricité", of the "Conférence Générale des Poids et Mesures") in order to compare the quality of the work done by national metrological laboratories. At present about ten cycles in the radiofrequency and microwave bands are in progress.

The practical arrangement of each cycle is committed to a "pilot laboratory" which supplies and circulates the "travelling standards", among the participating laboratories. Besides, the pilot laboratory collects and presents the results of the measurement cycle.

The IEN participated in the two above mentioned international intercomparison cycles, on field intensity and power density. The pilot laboratories involved were the National Bureau of Standards of the United States and the National Measurement Laboratory of Australia respectively.

The final results of these two measurement cycles are not yet known because the cycles are not yet completed. In the following sections only the measurement methods used at the IEN will be described and some comments about the results will be given.

1. FIELD INTENSITY MEASUREMENT CYCLE

To perform this measurement cycle a "travelling standard" has been realized and sent to all concerned laboratories by the pilot laboratory [1] .

The NBS transfer standard consists of the following elements: a dipole antenna with a diode detector mounted on a dielectric mast, and a direct current voltmeter with very high input impedance.

This voltmeter is calibrated against the direct voltage standard source kept by each participating laboratory. The antenna is a halfwavelength dipole with a nominal resonance frequency of 100 MHz and the detector connected directly to the antenna terminals is a selected Schottky diode; its breakdown voltage is about 70 volts to minimize the risk of damage due to static discharge.

Four diodes were supplied and the measurements were to be repeated for each of them.

Antenna and voltmeter are connected by a special bipolar cable about 3 m long; its leads are made of carbon-loaded teflon and its linear resistance is about 35 kΩ/m.

This special conductor, used to reduce the perturbations on the electromagnetic field, is followed by a normal bipolar shielded cable about 9 m long. The voltmeter includes an operational amplifier with input impedance of 200 MΩ and a four-digit display; it is supplied by a battery.

The measurement procedure is the following.

Before each measurement series it is recommended to calibrate the voltmeter against the direct voltage standard with an uncertainty less than 0.2%.

A wide open-air space without obstacles is required and an electromagnetic field at 100 MHz must be generated. The distance between the transmitting antenna and the receiving antenna (the travelling standard) must be at least 9m and the height of the latter one must be about 2.5 m above the ground. It is necessary to verify, by small vertical movements, that the receiving antenna is in a zone of maximum field.

The electromagnetic field intensity must be adjusted so as to read 100 ± 5 mV on the "transfer standard" voltmeter. Then the "transfer standard" antenna is replaced by the local standard antenna and the electric field is measured using a calibrated field intensity meter connected to the antenna by a normal shielded cable.

The measurements by both antennas must be repeated many times (at least in two different days) and it is necessary to change the measurement conditions, for example the transmitting-receiving antenna distance and the diode of the "transfer standard".

At last the local laboratory must send the measured values to the pilot laboratory, with information on the measurement conditions, for example the ground type and the weather conditions.

The measurements at the IEN were carried out on the new headquarters placed in Turin, Strada delle Cacce 91, in May 1977, with a field intensity of about 0.1 V/m. Obviously, nothing may be said on the evaluation of accuracy and on the agreement with the other laboratories, before the cycle is finished. However, the uncertainty of this particular electromagnetic field standard, realized at IEN with the experimental conditions reported above, can be estimated about ± 1.5 dB.

This figure stems from the following considerations:

- the uncertainty of the field-strength meter, calibrated against a known r.f. source, was about ± 0.5 dB;
- the coaxial cable attenuation was measured with an uncertainty of ± 0.2 dB;
- the three terms, that combine to make the local half-wavelength dipole coefficient, are the effective height (λ/π), the mismatch between 72 ohm antenna and 50 ohm cable (1.7 dB), and the conversion to open circuit voltage (6 dB). The uncertainty of the antenna coefficient depends mainly on the dipole impedance which may be different from 72 ohm. In the worst case, taking into account the test set-up used, the error should not be greater than 0.5 dB;
- nothing can be said about the perturbations on the electromagnetic field produced by the coaxial cable employed.

The other participating laboratories were:

FTZ - Fernmelde Technisches Zentralamt (West Germany)
NML - National Measurements Laboratory (Australia)
BRH - Bureau of Radiological Health (U.S.A.)
NPL - National Physical Laboratory (U.K.)
RIND - Research Institute of National Defence (Sweden)

2. POWER DENSITY MEASUREMENT CYCLE

The CCE, having decided to organize a power density measurement cycle, chose the frequency of 2.45 GHz, because this value is reserved for industrial uses and there are many applications with considerable power. Moreover, simple power density meters are available on the market for controlling the radiation level in the environment. Several countries accept a standard that admits as tolerable a level of 10 mW/cm^2, though with variations to account for the exposure time. Therefore the CCE suggested to adopt this reference level and to use commercial instruments, in order to investigate if they are suitable to secure an adequate level control of the electromagnetic radiation.

For this measurement cycle, the pilot laboratory supplied a set of commercial power density meters, which were the "travelling standard" for the other laboratories.

The measurement method is different from the previous one, because in this case each laboratory measures a calculated field by the same instrumentation rather than compare its own instruments with the "travelling standard".

The main difficulty is the practical impossibility to generate a plane wave in the laboratory. It is known that only approaching this condition it is possible to calculate the power density in the measurement site from the power delivered by the generator, with satisfactory approximation. Good results would be obtained if one operates in the open space and over long distances (with respect to the wavelength used) in order to reduce the perturbative effects produced by obstacles, including the ground.

This procedure is rather unpractical and very expensive, especially regarding the generator, when relatively high power densities are required, as in this situation. Then one must accept the solution to operate in anechoic chambers, where, by studying the geometry and using absorbing material appropriately, a useful measurement zone, generally called "quiet zone", is obtained, in which the electromagnetic field is analitically computable.

More or less elaborate procedures have been perfected in all participating laboratories and these allow to generate a known electromagnetic field in the "quiet zone", with an uncertainty of ± 1 dB [2,3]. The procedure adopted by the IEN is not particularly sophisticated, since it requires only commercial instrumentation, and allows to obtain calibrations at 2.45 GHz with a power density level of 10 mW/cm^2, operating over a transmitter-receiver distance of about 4 m and with a 150 W generator. The uncertainty achieved is about ± 1.5 dB in a zone of 0.5 m diameter approximately.

Figure 1 shows the instrumentation used. The 2.45 GHz radiofrequency power, generated by a magnetron, is radiated by a "standard horn" into the anechoic chamber, and the power density S of the electromagnetic field is:

$$S = \frac{GP}{4\pi d^2} \qquad (d \rightarrow \infty) \tag{1}$$

where G is the antenna gain, P the power supplied to the antenna, d the transmitting-receiving antenna distance. Obviously (1) is only exact in ideal propagation conditions. The measuring set, consisting of the power meters A and B, and the double directional coupler C, is used to determine the actual power radiated by the antenna $P = P_A - P_B$ with P_A = power supplied by the generator, P_B = power reflected by the antenna. The instrument under calibration is represented on the right side of figure 1. The probe of the power density meter is mounted on a carriage and can be moved inside the anechoic chamber.

The analogic output of the power density meter is sent to the y axis of a x-y recorder, whereas a position transducer supplies the x axis with a signal directly proportional to the transmitting-receiving antenna distance. The power density curve (versus antenna position) recorded along the longitudinal axis of the chamber, allows to evaluate the VSWR (at least in this direction) and then to estimate the field uniformity. Moreover, from the recording it is possible to derive by statistical methods a corrected power density value R and then the calibration factor K of the instrument:

$$K = S / R \tag{2}$$

The main error in the K evaluation is due to R, since the uncertainty in the P,G and d determination is lower. Certainly other causes of error exist, for example the influence of induction field components, but in this case they do not contribute significantly.

The K-factor is the result that each participating laboratory in the cycle sends to the pilot laboratory together with the general test conditions. Also in this case the final data of the measurement cycle are not yet available, but it is possible to estimate that the commercial instrumentation can be calibrated with an uncertainty of ± 2 dB.

A more detailed error budget is being considered end is expected to be calculated before the end of the cycle.

The other participating laboratories were:

BRH - Bureau of Radiological Health (U.S.A.)
NBS - National Bureau of Standards (U.S.A.)
NPL - National Physical Laboratory (U.K.)
RIND - Research Institute of National Defence (Sweden)

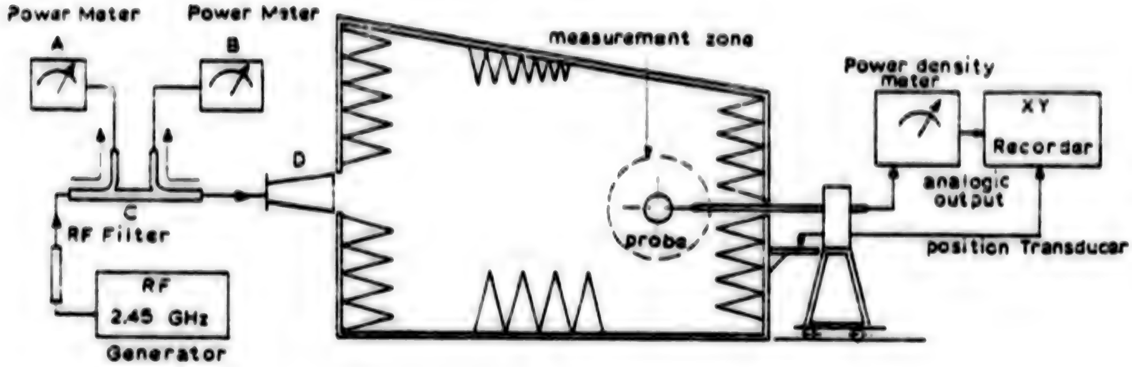

Fig. 1 - Schematic diagram of the experimental set-up for power density meter calibration.

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Radiation Measurement Site Suitability

Milan ALTA FREQUENZA in English Mar-Apr 80 pp 163-171

[Text] ABSTRACT

Procedures to assess the test site suitability for radiation measurements are considered and discussed with special care to the IEC standard 3-metre method.

The so called "calibration curves" are given for the frequency range from 30 to 1000 MHz in terms of "site attenuation" and "calculated field intensity".

INTRODUCTION

All different methods of measurement of radiation from electrical appliances require to operate in open air on a suitable site, free from reflections.

IEC and CISPR Publications and other Standards recommend a site flat and free from reflecting objects on an area the dimensions of which depend on the standard distance lying between the radiating appliance under test and the receiving antenna.

However, in practice, it is very difficult to avoid reflections because reflecting objects, like walls, trees and so on, even at distances greater than those recommended by Standards, can influence the results. In order to establish whether a site can be used or not for radiation measurements, some tests should be carried out and the most used one is to compare the experimental results with the theoretical ones. In other words, if the experimental results do not differ more than a certain amount (e.g. 3 dB) from the values calculated for the ideal conditions of propagation and ground reflection, the site is considered suitable for radiation measurements.

1. SITE SUITABILITY

The suitability of the site should be checked with the standard set-up recommended for radiation measurements but replacing the radiating appliance with a radiating device whose characteristics are known and reproducible, e.g. a transmitting dipole, supplied by a known power.

The testing set-up is then shown in Fig. 1, where A_1 is the transmitting antenna supplied by the standard generator G, and A_2 is the receiving antenna connected to the input of the field-strength meter M.

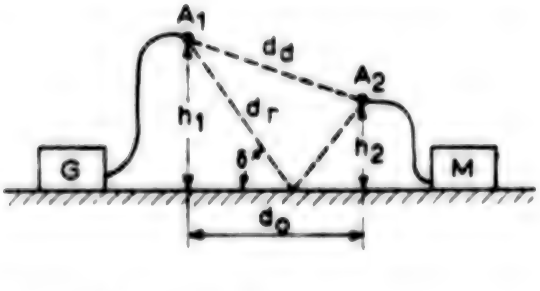

Fig. 1 - Test set-up

Two different kinds of procedure are now available, according to field or attenuation calculation and measurement.

1.1. Field method

This procedure consists in calculating the field at the centre of the receiving antenna when a given power is supplied to the transmitting antenna. The field is then measured with the field-strength meter and the calculated and measured values are compared.

The field calculation is easy only in the ideal case of far-field conditions and when the influence of the soil on the impedance of the two antennas is neglected. In this case the field at the centre of the receiving antenna can be calculated as the vectorial sum of the fields generated by the transmitting antenna A_1 and by its image A_1' with respect to the ground (Fig. 2).

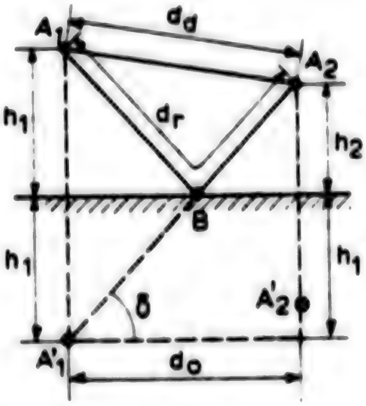

Fig. 2 - Measuring site geometry

If A_1 is a horizontal tuned dipole in free space, it follows:

$$\bar{E}_d = \frac{7\sqrt{P_t}}{d_d}\, e^{-j\beta d_d} \qquad (1.1)$$

where:

$\bar{E}_d$ is the electric field vector at the centre of the receiving antenna

P_t is the power supplied to the transmitting antenna

$\beta = 2\pi/\lambda$ is the propagation constant

$d_d = \sqrt{(h_1-h_2)^2 + d_o^2}$ is the direct-wave path

Taking into account the ground reflection, the field intensity becomes:

$$(1.2) \qquad E = E_d\, q$$

in which:

E_d is the field intensity in free space

q is a coefficient to take into account the effect of the ground reflection; it may be expressed:

$$(1.3) \qquad q = \left| 1 + \rho \frac{d_d}{d_r}\, e^{-j[\beta(d_r - d_d) - \phi]} \right|$$

where:

$d_r = \sqrt{(h_1+h_2)^2 + d_o^2}$ is the reflected-wave path

ρ and ϕ are the magnitude and phase lag of the ground reflection coefficient Γ (*).

1.2. Attenuation method

This procedure is based on the following definition of site attenuation:

$$(1.4) \qquad A_p = P_t / P_r$$

where:

A_p is the site attenuation

P_t is the power supplied to the transmitting antenna A_1

P_r is the power supplied to the input of the field-strength meter by the receiving antenna A_2 (+)

Let the equivalent circuit diagram be as shown in Fig. 3.

The impedances Z_{i1} and Z_{o2} may be deduced from the following equations that apply to the antenna system consisting of A_1, A_2 and their images A_1', A_2' [2]:

$$(1.5) \qquad \begin{aligned} V_1 &= I_1 Z_{11} + \Gamma I_1 Z_{11'} + I_2 Z_{12} + \Gamma I_2 Z_{12'} \\ V_2 &= I_1 Z_{21} + \Gamma I_1 Z_{21'} + I_2 Z_{22} + \Gamma I_2 Z_{22'} \end{aligned}$$

in which:

Γ is the complex reflection coefficient of the ground;

$Z_{ij} = Z_{ji}$ is the mutual impedance between A_i and A_j antenna.

Considering that $V_2 = -I_2 Z_L$, where Z_L is the load impedance at the receiving antenna terminals, it results from eq. (1.5):

$$(1.6) \qquad Z_{i1} = \frac{V_1}{I_1} = Z_{11} + \Gamma Z_{11'} - \frac{(Z_{12} + \Gamma Z_{12'})^2}{Z_{22} + \Gamma Z_{22'} + Z_L}$$

likewise:

$$(1.7) \qquad Z_{o2} = \frac{V_2}{I_2} = Z_{22} + \Gamma Z_{22'} - \frac{(Z_{12} + \Gamma Z_{12'})^2}{Z_{11} + \Gamma Z_{11'} + Z_g}$$

in which Z_g is the impedance of the equivalent generator at the transmitting antenna terminals.

Besides, it is possible to derive from eq. (1.5) the ratio of the induced e.m.f. V_{2o} of the receiving antenna to the current I_1 feeding the transmitting antenna:

$$(1.8) \qquad Z_m = \frac{V_{2o}}{I_1} = (Z_{12} + \Gamma Z_{12'})\left(1 - \frac{\Gamma Z_{22'}}{Z_{22} + \Gamma Z_{22'} + Z_L}\right).$$

An expression for site attenuation A_p can now be deduced from the knowledge of Z_{i1}, Z_{o2} and Z_m.

(+) Elsewhere, the power P_r is defined as the available power of the receiving antenna [1]. This definition leads to a less general expression of the attenuation A_p, valid only when the receiving antenna is matched to the field-strength meter (see below eq. (1.11a)).

(*) For a horizontally polarized plane-wave:

$$\Gamma = \rho e^{j\phi} = \frac{\sin\delta - \sqrt{\varepsilon' - \cos^2\delta}}{\sin\delta + \sqrt{\varepsilon' - \cos^2\delta}}$$

with

$$\varepsilon' = \varepsilon_r \left(1 - j\, \frac{18 \times 10^9}{f}\, \frac{\sigma}{\varepsilon_r}\right) \text{ and:}$$

δ = $\arctan(h_1 + h_2)/d_o$ is the angle of incidence

f is the frequency

σ is the ground conductivity

ε_r is the relative dielectric constant of the ground (referred to free space as unity).

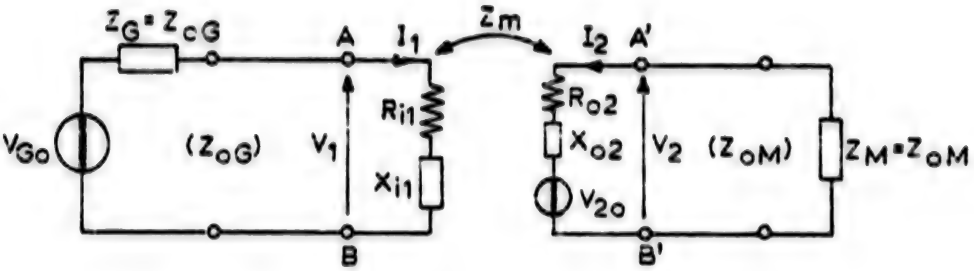

Fig. 3 - Equivalent circuit diagram.

V_{Go} = e.m.f. of the signal generator
Z_G = output impedance of the signal generator
Z_{oG} = characteristic impedance of the feeder connected to the generator
Z_M = input impedance of the field-strength meter
Z_{oM} = characteristic impedance of the feeder connected to the field-strength meter
$Z_{i1} = R_{i1}+jX_{i1}$ = input impedance of the transmitting antenna
$Z_{o2} = R_{o2}+jX_{o2}$ = output impedance of the receiving antenna
V_{2o} = e.m.f. induced at the open terminals of the receiving antenna
$Z_m = V_{2o}/I_1$ = transfer impedance

Referring to the circuit diagram of Fig. 3, in which, as usually occurs in practice, the output impedance Z_G of the signal generator and the input impedance Z_M of the field-strength meter are real and matched to their own feeder, the power P_t is given by:

$$P_t = \left| \frac{V_{Go}}{Z_G + Z_{i1}} \right|^2 R_{i1} \tag{1.9}$$

and P_r by:

$$\begin{aligned} P_r &= \left| \frac{V_{2o}}{Z_M+Z_{o2}} \right|^2 Z_M = \left| \frac{I_1 Z_m}{Z_M+Z_{o2}} \right|^2 Z_M = \\ &= \frac{|V_{Go}|^2}{|Z_G+Z_{i1}|^2} \; \frac{|Z_m|^2}{|Z_M+Z_{o2}|^2} Z_M \end{aligned} \tag{1.10}$$

then:

$$A_p = \frac{P_t}{P_r} = \frac{|Z_M + Z_{o2}|^2}{|Z_m|^2} \; \frac{R_{i1}}{Z_M} \tag{1.11}$$

When the receiving antenna is matched to the field-strength meter, the expression (1.11) becomes:

$$A_p = 4 \frac{R_{o2} R_{i1}}{|Z_m|^2} \tag{1.11a}$$

If the distance between antennas is great enough (at least one wavelength) so that the far-field conditions can be considered, then the following expressions apply:

$$|V_{2o}| = h_e E \text{ and } E = \frac{\sqrt{30G_t}\sqrt{P_t}}{d_d} q \tag{1.12}$$

where h_e is the effective height of the receiving antenna, G_t is the gain of the transmitting antenna (referred to the isotropic radiator) and the other symbols are the same as defined before. .

In this case:

$$P_r = \frac{h_e^2 30 G_t P_t q^2}{d_d^2} \; \frac{Z_M}{|Z_M + Z_{o2}|^2} \tag{1.13}$$

then:

$$A_p = \frac{P_t}{P_r} = \frac{|Z_M+Z_{o2}|^2}{Z_M} \; \frac{d_d^2}{30 G_t h_e^2 q^2} \tag{1.14}$$

Finally, if the following conditions are considered:

- the antennas are two horizontal half-wave dipoles:

$$h_e = \lambda/\pi \qquad G_t = 1.64 \tag{1.15a}$$

- the heights of the dipoles above ground as well as the distance d_o are great enough so that the contribution of mutual impedances Z_{ij} (with $i \neq j$) can be neglected and the equations (1.6) and (1.7) give the impedances in free-space conditions:

$$Z_{i1} = Z_{o2} \tag{1.15b}$$

- the transmitting and receiving antennas are matched to the signal generator and the field-strength meter respectively

$$Z_{i1} = Z_G \qquad Z_{o2} = Z_M \tag{1.15c}$$

- the dipoles are self-resonant:

$$R_{i1} = R_{o2} = 73.2\ \Omega \qquad X_{i1} = X_{o2} = 0 \tag{1.15d}$$

the expression (1.14) becomes: (+)

$$A_p = \frac{73.2}{30\times1.64}\left(\frac{2\pi d_d}{\lambda q}\right)^2 \tag{1.16}$$

In practice it is more convenient to measure voltages rather than the powers P_t and P_r; so, it is possible to give another definition of site attenuation based on a substitution method:

$$A_v = V'_{Go}/V''_{Go} \tag{1.17}$$

where:

A_v is the site attenuation

V'_{Go} is the signal generator e.m.f. for a convenient deflection V_M on the field-strength meter when the antennas are arranged according to the test set-up of Fig. 1

V''_{Go} is the signal generator e.m.f. for the same deflection V_M when the connections A-A', B-B' of Fig. 3 are connected directly together, excluding the antennas.

In this way one takes also into account the losses of the feeders and of matching pads and baluns, if any, since they are present during both measurements. Moreover, a correct calibration of the field-strength meter is not required. According to this new definition, an expression for site attenuation A_v can be deduced from the circuit diagram of Fig. 3 in a way similar to that followed above: taking into account the ground reflection effect (coeff. q) and considering that the two antennas are half-wave dipoles ($G_t = G_r = 1.64$).

$$A_v = \frac{V'_{Go}}{V''_{Go}} = \frac{|Z_M + Z_{o2}|}{|Z_m|}\ \frac{|Z_G + Z_{i1}|}{Z_G + Z_M} \tag{1.18}$$

In far-field conditions where relations (1.12) apply:

$$A_v = \frac{|Z_M + Z_{o2}|}{Z_G + Z_M}\ \frac{|Z_G + Z_{i1}|}{\sqrt{R_{i1}}}\ \frac{d_d}{\sqrt{30G_t}\,h_e q} \tag{1.19}$$

Finally, considering conditions (1.15), the expression (1.19) becomes:

$$A_v = \sqrt{\frac{73.2}{30\times1.64}}\left(\frac{2\pi d_d}{\lambda q}\right) \tag{1.20}$$

Comparing eq. (1.16) with (1.20) if follows:

$$A_p = A_v^2 \tag{1.21}$$

i.e. the two site attenuations are equal when expressed in dB.

It should be pointed out that also expressions (1.11) and (1.18) satisfy eq. (1.21) when the matching conditions (1.15c) occur and the signal generator and field-strength meter have the same impedance ($Z_G = Z_M = Z_o$): in this case it follows:

$$A_p = A_v^2 = (2\ Z_o/|Z_m|)^2\ . \tag{1.22}$$

1.3. Remarks on the use of site attenuation formulae

When expression (1.16) or (1.20) is used, no problem arises about matching antennas to their feeder, because it was assumed that antennas have a real and constant impedance against the frequency (e. g. 73.2 Ω). When expression (1.11) or (1.18) is used, the actual calculated impedances of transmitting and receiving antennas have to be taken into account.

The most logical situation to be considered should be that in which each antenna is correctly matched to the generator and the field-strength meter respectively so that conditions (1.15c) are satisfied. In this case, not only relation (1.11a) applies to calculate the site attenuation A_p, but direct measurements of

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(+) The same expression can be obtained from the formula giving the received power in free-space [12]

$$P_r = P_t G_t G_r \lambda^2/(4\pi d_d)^2,$$

power are avoided, because P_t and P_r become the available power of the generator $P_t = V_{0t}^2/4Z_1$ and of the receiving antenna $P_r = V_{2o}^2/4R_{22} = V_2^2/Z_u$ respectively and can be easily measured.

Unfortunately, this situation would be meaningless in practice, because it implies to use an unrealistic matching transformer, which at each measuring frequency should be set for correct compensation of the imaginary part of the antenna impedance and correct matching of the real part to the feeder impedance (e.g. 50 Ω).

In the contrary, more realistic operating conditions may be the following:

i) Both antennas are tuned according to the manufacturer instructions. In this case the antenna length is less than $\lambda/2$ and it can be supposed that the imaginary part of its free-space impedance vanishes. The mutual impedance Z_m and antenna impedances Z_{11} and Z_{22} should be calculated by means of complicated formulae valid for $L \neq \lambda/2$ [3].

ii) The length of the two antennas is set exactly equal to $\lambda/2$. In this case mutual impedances can be calculated through simpler formulae [4], but the imaginary part of the impedances Z_{11} and Z_{22} could be compensated by using suitable matching stubs at the antenna terminals. This situation corresponds to put in formula (1.11) or (1.18) R_{11} and R_{22} instead of Z_{11} and Z_{22} respectively. In both cases, moreover, ideal baluns having a 1:1 ratio are considered.

2. THE SUITABILITY OF THE IEC RADIATION MEASUREMENT SITE

The procedure to check the suitability of the radiation measurement site is described in Section Six of IEC Publication 106 [5]. In this case the field method was chosen, giving the available power against the frequency for a constant field intensity of 100 µV/m.

The radiating antenna is the same standard antenna to be connected to the receiver under test, that is a dipole of fixed length (1.5 m for the frequency range 30 to 300 MHz and 0.3 m for the frequency range 300 to 1000 MHz); owing to the fact that the dipole is not matched to the standard generator, some difficulties arose in calculating the available power.

Besides, it should be kept in mind that the IEC curve for the frequency range 30 to 300 MHz was given taking into account not only the theoretical curve but also the experimental results obtained in Italy and United Kingdom at that time [6], whereas the curve for the frequency range 300 to 1000 MHz was merely theoretical. In both cases, the theoretical values were calculated by means of the following formula [5]:

$$P = P_0\,\alpha\,G \qquad (2.1)$$

where:

P the available power of the generator

P_0 is the power required by a tuned dipole to give a field E = 100 µV/m at the centre of the receiving antenna, whose height has been set for maximum reading

α is the mismatch loss due to the transmitting antenna impedance, different from 300 Ω

G is the gain of the transmitting antenna of fixed length with respect to a half-wave dipole.

The power P_0 was calculated through the formulae (1.1), (1.2) and (1.3), in which P_t is replaced by P_0 and the factor q takes the simple expression:

$$q = 1 + d_d/d_r \qquad (2.2)$$

because a metal wire mesh on the ground is recommended (soil reflection assumed to be ideal: $\rho = 1$, $\phi = \pi$) and only the heights h_2 giving maximum readings are considered ($\beta(d_r - d_d) = (2n+1)\pi$).

It should be noted that the theoretical results are correct only for far-field conditions, that is when the distance d_d between antennas is more than one wavelength. Since in IEC method the distance d_d is about 3 m, the far-field conditions are certainly satisfied in the frequency range 300 to 1000 MHz.

Nevertheless, measurements performed by the Home Office [7] on different sites in London and its surroundings have given results in disagreement with the IEC curves, especially in the frequency range above 300 MHz, where the simplified theory ought to be in better agreement with the actual situation.

The discrepancies between experimental and theoretical results may be due to several reasons; the most important among them are the following:

- from the experimental side:

a) the untuned antenna can have an impedance very different from that given by the theory, especially as far as the imaginary component is concerned;

b) the balun can introduce stray reactive components;

c) the balanced feeder connecting the generator to the untuned dipole can radiate, giving spurious field components;

- from the theoretical side:

d) the effect of the soil and receiving antenna is not taken into account in calculating the impedance of the transmitting antenna and then the available power;

e) the field intensity is calculated at the centre of the receiving antenna and supposed constant along it;

f) the field intensity is supposed linearly decreasing with the distance;

g) the formula used to calculate the field intensity is valid only for far-field conditions;

h) no indication is given about which antenna height has to be considered: when moving the receiving antenna in the range from 1 to 4 m above the ground several maxima of the reading occur.

Analyzing the above listed reasons, the following conclusions can be drawn in order to improve the results:

- the consequences due to the reasons a) and c) can be avoided by using a tuned dipole as a transmitting antenna and a screened coaxial cable instead of the balanced feeder;
- points d) to g) are of interest only at lower frequencies, when the far-field situation does not yet occur.

3.1. A first-approximation solution (simplified method)

The above reason a) is the most responsible for errors in calculating the site curves, because the relations giving the impedance of an untuned dipole are very complicated. If simpler relations are used, which do not take into account the diameter-to-length ratio of the antenna, very different results may be obtained in calculating the antenna impedance and then the site curves. An example for the frequency range 300 to 1000 MHz is given in Fig. 4, where the calculated impedance (real and imaginary part) of the IEC standard dipole of fixed length (0.3 m) is shown: very great differences are found using different graphs and formulae, especially at higher frequencies [7,8,9,10]. The respective site curves are shown in Fig. 5, where the IEC curve of Pub. 106 is also drawn for comparison [5].

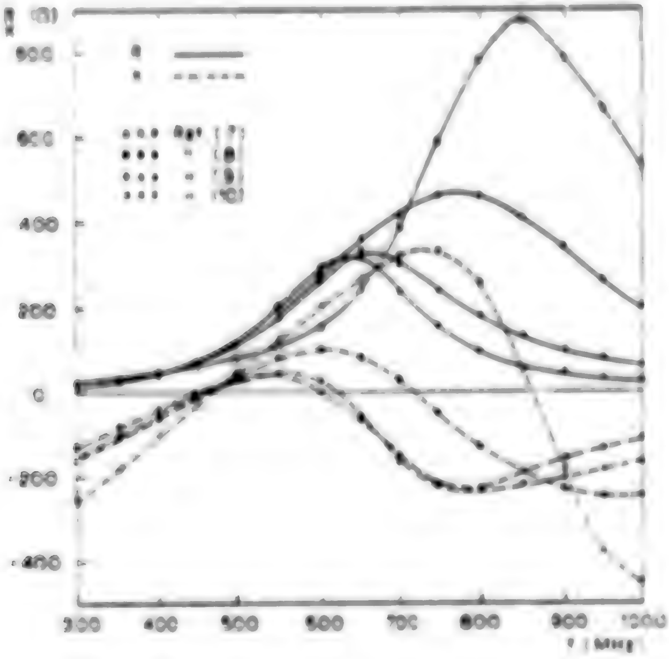

Fig. 4 - Calculated impedance (real and imaginary part) of an untuned dipole, according to different theories

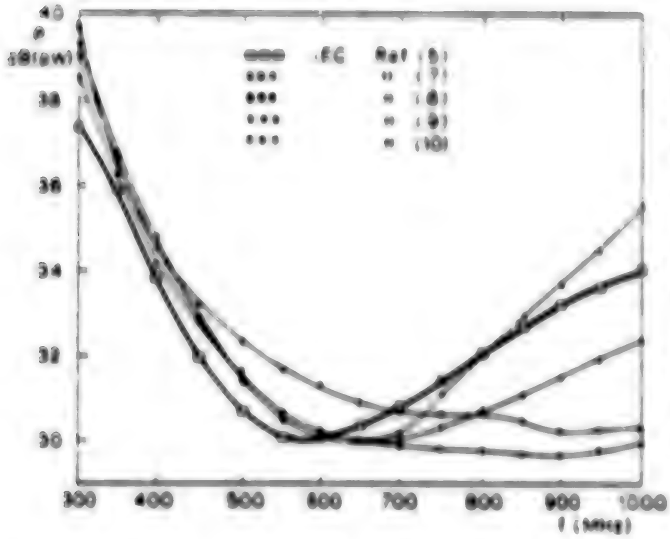

Fig. 5 - Site curves corresponding to the different cases of Fig. 4, compared with IEC curve

The curves of Fig. 5 can very well explain why different theoretical results as well as discrepancies with the experimental ones were found.

A first step to simplify the site curve calculation and to reduce the discrepancies between calculated and measured values is taken by using a tuned transmitting dipole, as already mentioned.

In this case, the antenna impedance can be assumed independent of the frequency and equal to about 73 Ω. The power P_0 required to generate a field intensity of 100 µV/m is approximately constant and very close to 30 dB(pW).

A more exact value of P_0 can be calculated taking into account the height of the receiving antenna for maximum reading.

The power P_0 at the transmitting antenna terminals is then given by formulae (1.1), (1.2) and (2.2) and plotted in Fig. 6 as a function of the receiving antenna height h_2.

The curve of Fig. 6 shows that a minimum value of P_0 is required when the maximum reading occurs at a height h_2 of about 3.6 m (the height h_1 of the transmitting dipole being 4 m), whereas the maximum power P_0 is required when $h_2 = 1$ m. Nevertheless, the difference between the maximum and minimum values is about 1 dB only.

In this way (i.e. with a tuned transmitting dipole) the uncertainty due to the above indicated reason a) can be avoided and the available power P at the output of the standard generator is given by the following formula:

$$P = P_0 \, \alpha_c \tag{2.3}$$

where α_c is the loss of the feeder and balun [11].

The uncertainty due to the reason c) can be avoided by using a well screened coaxial feeder having the same impedance as the standard generator, and a tuned dipole with an unbalanced input, like those commonly supplied together with the field-strength meters.

Furthermore, to avoid uncertainties due to reasons a) to g), the far-field conditions should be satisfied. That means to limit the lower end of the frequency range to about 50-100 MHz, as already mentioned. The above described criteria have been considered by Working Group 1 (Radiation and Immunity Measurements) of the IEC Sub-Committee 12A (Receiving Equipment) in revising Section Six - Radiation Measurement Site - of the present Pub. 106. In order to introduce a further simplification in checking the site suitability, the site attenuation was adopted and defined according to relation (1.4) or (1.17), which in this case take the expressions (1.16) and (1.20) respectively.

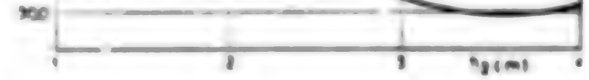

Fig. 6 - Available power at the tuned transmitting dipole terminals to produce a field of 100 µV/m

The site attenuation A is then given in dB as a function of the frequency in the range 80 to 1000 MHz (Fig. 7), for a specified height h_2 of the receiving antenna (Fig. 8) corresponding to a maximum reading on the field-strength meter [12].

Since the frequency range starts from 80 MHz, it can be considered that far-field conditions are satisfied.

Nevertheless, it should be pointed out that in practice the range limitation to 80 MHz does not restrict the use of the method, because the minimum radiation frequency from TV and FM receivers generally falls above 87 MHz (for standard TV i.f.'s of 33.4 and 38.9 MHz and for supradyne FM receivers).

2.2. A second-approximation solution (Mutual impedance method)

To improve furthermore the accuracy of the site attenuation calculation, the influence of the soil as well as the influence of the receiving antenna on the transmitting antenna impedance should be taken into account.

From the theoretical point of view, when the mutual impedances between the transmitting and receiving antennas and between each antenna and its image with respect to the ground are considered, the induced e.m.f. in the receiving antenna can be directly calculated through the mutual impedance of the system Z_m, given by Eq. (1.5), regardless of far- or near-field conditions.

Therefore, formulae (1.11) and (1.18) have no restriction with regard to the frequency and can apply to calculate the site attenuation down to 30 MHz.

Moreover, both antennas may be tuned or untuned, but they should have the same size (length and diameter) for the sake of simplicity in calculating the mutual impedances.

In far-field conditions and when both antennas are not too close to the ground, the results of the mutual impedance method and those of the simplified method differ by a small amount [1],[13].

Of course, the two methods become equivalent in free-space and far-field conditions.

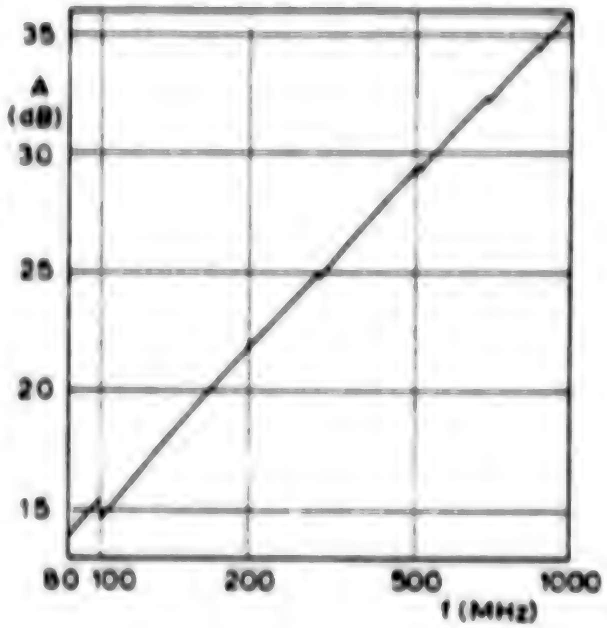

Fig. 7 - Theoretical site attenuation curve obtained with receiving antenna height of Fig. 8

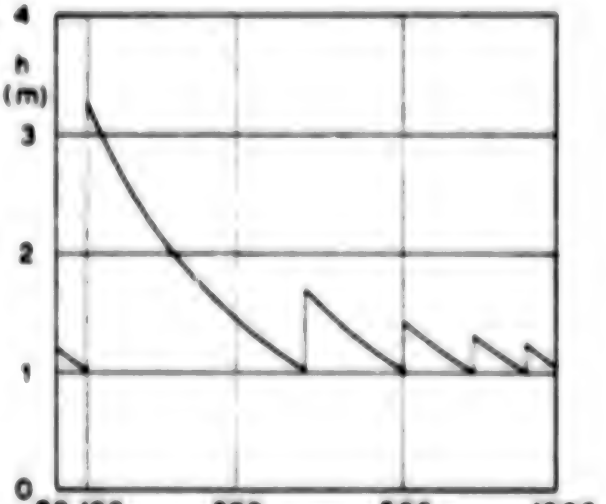

Fig. 8 - Theoretical antenna height for maximum reading on the meter

3. CONCLUSIONS

In far-field conditions (about 80 to 1000 MHz) the site attenuation curve can be calculated by means of formula (1.16) or (1.20) and the curve of Fig. 7 can be considered acceptable.

Nevertheless, an improvement can be introduced considering that the influence of the soil on the antenna impedance, and then the error in calculating the site attenuation, is reduced when the antennas are as far as possible from the ground.

For this reason it may be suggested to keep the transmitting antenna at $h_1 = 4$ m and to consider, for example, the first maximum reading below 4 m, instead of the first one above 1 m.

Furthermore, the difference between the highest and lowest values of the site attenuation, occurring when the receiving antenna is moved up and down through its whole search range, is less than 1 dB, as it can be deduced from the curve of Fig. 6; therefore the site attenuation curve can be given regardless of the position of the receiving antenna.

In fact, the curve of Fig. 7 can be replaced by two straight lines (Fig. 9), corresponding to the highest and lowest attenuation values. The equations of these lines are derived from eq. (1.16) or (1.20) for $h_1 = 1$ m and 3.615 m, which are the values giving the highest and lowest attenuation respectively, according to the curve of Fig. 6.

Taking into account eq. (2.2) and introducing the frequency f instead of the wavelength λ in eq. (1.16) or (1.20) it follows:

$$\begin{aligned} A(\mathrm{dB}) &= 20\log f - 24.97 \quad \text{(lowest value)} \\ A(\mathrm{dB}) &= 20\log f - 24.05 \quad \text{(highest value)} \end{aligned} \tag{3.1}$$

where the frequency is expressed in MHz and the attenuation is given in dB. In this way, the site is considered satisfactory for radiation measurements when the measured attenuation, regardless of the height of the receiving antenna, falls between the two lines, with a tolerance of ± 3 dB as specified in IEC Publication 106.

The attenuation curve calculated by mutual impedance method according to eq. (1.18) and the above specified conditions ii) is plotted in Fig. 9 for comparison.

This curve is split up into five parts corresponding to different orders of the maximum reading, as shown in Fig. 9, where n indicates the nth maximum above ground. Consequently, the receiving antenna height should be set in the following ranges, as indicated in Table I, for maximum reading.

TABLE I

h_2 (m)	f (MHz)	n
4.06 - 2.24	80 - 140	2
3.60 - 1.95	140 - 250	3
3.80 - 2.15	250 - 410	5
4.00 - 2.15	410 - 680	8
4.00 - 2.46	680 - 1000	13

As it is shown in Fig. 9, the difference between the curves calculated by the simplified and mutual impedance methods is very small, less than 1 dB, except for a few points, which fall outside the two straight lines. Nevertheless, the difference can be considered small with respect to the usual accuracy of the radiation measurements.

In near-field conditions (below about 80 MHz), the site attenuation can be calculated only by means of eq. (1.11) or (1.18). The curve plotted in Fig. 9 for the frequency range 30 - 80 MHz was calculated with reference to eq. (1.18) and conditions ii), in the same way as the curve for frequencies above 80 MHz, and compared with the adjacent straight line obtained from eq. (1.20) for far-field conditions.

The receiving antenna height h_2 varies from 4 to 1.8 m in the frequency range 42 to 80 MHz, in which only the first maximum above ground exists (n = 1). At frequencies below 42 MHz, the maximum reading occurs for h_2 greater than 4 m and then it cannot be reached in practice. Therefore, in this range the curve was calculated for a fixed height $h_2 = 4$ m.

As mentioned above, only eq. (1.18) relating to the site attenuation A_v was used, because it is more convenient in practice to measure voltages rather than powers.

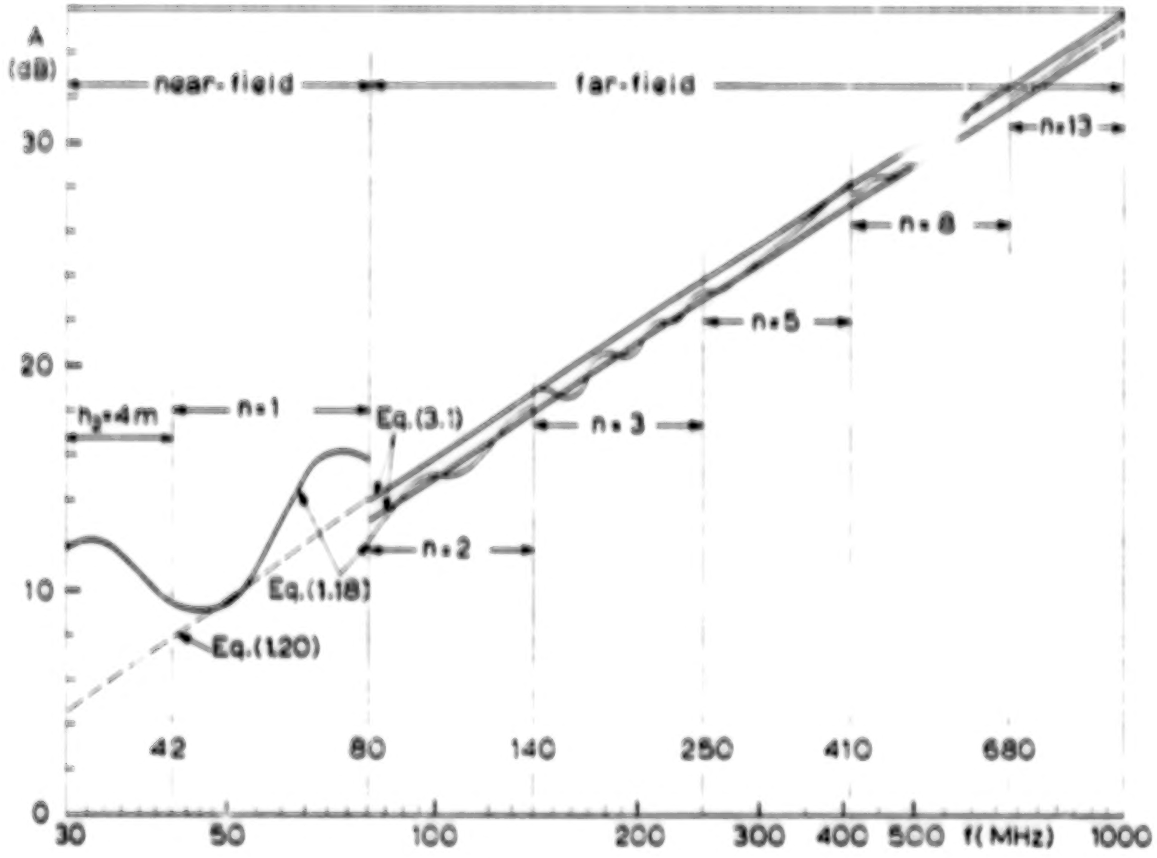

Fig. 9 - Comparison between site attenuation curves calculated by simplified method and by mutual impedance method

Moreover, only conditions ii) were considered and the mutual impedances were calculated for infinitesimally thin antenna [4].

At the IEN investigations are in progress to calculate the attenuation curve also in conditions i), closer to the real measurement conditions, in order to determine the influence of the diameter and length of the antennas on the results.

Moreover an experimental investigation will be carried out in the frequency range 30 - 80 MHz to compare the theoretical values with the results obtained by using non-standard dipoles, like those usually supplied together with the field-strength meters available on the market.

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